PB-230 817

POLLUTION OF THE INTERSTATE WATERS OF THE COLORADO RIVER AND ITS TRIBUTARIES, COLORADO, NEW MEXICO, ARIZONA, CALIFORNIA, NEVADA, WYOMING, UTAH. PROCEEDINGS OF CONFERENCE, SESSION (7TH) HELD AT DENVER, COLORADO ON APRIL 26-27, 1972. RECONVENED.

Environmental Protection Agency
Washington, D.C.

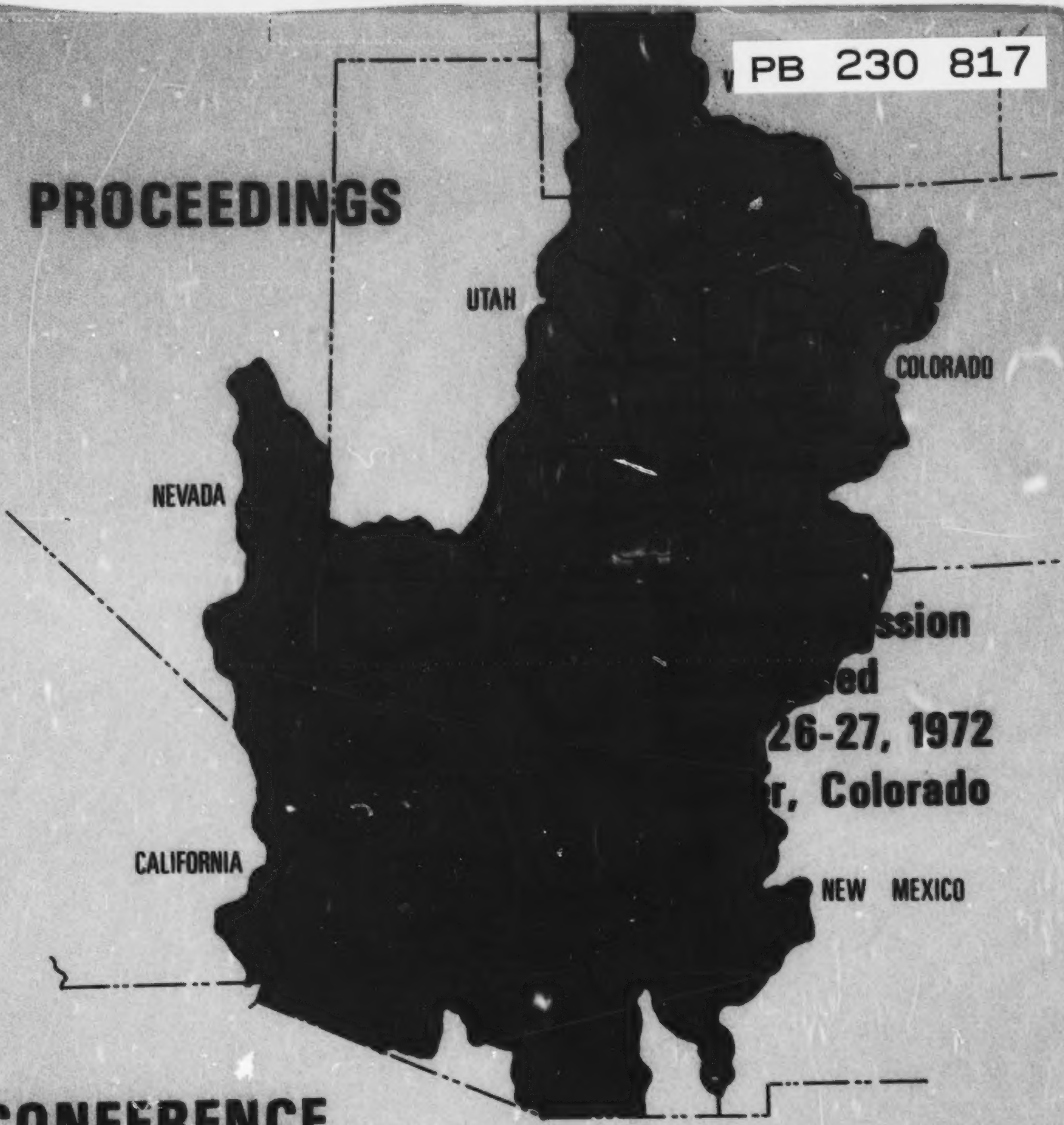
27 April 1972

DISTRIBUTED BY:

NTIS
National Technical Information Service
U. S. DEPARTMENT OF COMMERCE
5285 Port Royal Road, Springfield Va. 22151

PB 230 817

PROCEEDINGS


W
UTAH
COLORADO
NEVADA
CALIFORNIA
NEW MEXICO

ssion
ed
26-27, 1972
r, Colorado

CONFERENCE

In the Matter of Pollution of the Interstate Waters of the Colorado River and its Tributaries - Colorado, New Mexico, Arizona, California, Nevada, Wyoming, Utah.

ENVIRONMENTAL PROTECTION AGENCY

Reproduced by
NATIONAL TECHNICAL
INFORMATION SERVICE
U S Department of Commerce
Springfield VA 22151

183

i

RECONVENED SEVENTH SESSION
OF THE
CONFERENCE
IN THE MATTER OF
POLLUTION OF THE INTERSTATE WATERS OF THE COLORADO RIVER AND ITS TRIBUTARIES IN THE STATES OF CALIFORNIA, COLORADO, UTAH, ARIZONA, NEVADA, NEW MEXICO, AND WYOMING

held in

Denver, Colorado

April 26-27,1972

TRANSCRIPT OF PROCEEDINGS

The report is on [illegible]

The Seventh Session of the Conference in the Matter of Pollution of the Interstate Waters of the Colorado River and its tributaries in the States of California, Colorado, Utah, Arizona, Nevada, New Mexico, and Wyoming reconvened at 2 o'clock on April 26, 1972, in Denver, Colorado.

It includes statements, discussions, and recommendations on: Water quality improvement programs, concentration of total dissolved solids, water quality data, and related information.

PRESIDING:

Murray Stein
Chief Enforcement Officer - Water
U. S. Environmental Protection Agency
Washington, D. C.

CONFEREES PRESENT ON APRIL 26:

Irwin L. Dickstein
Director, Enforcement Division
Region VIII, U. S. EPA
Denver, Colorado

Norman B. Hume
Member, State Water Resources
Control Board
Sacramento, California

Richard L. O'Connell
Director, Enforcement Division
Region IX, U. S. EPA
San Francisco, California

Frank Rozich
Director, Water Pollution Control Division
Colorado Department of Health
Denver, Colorado

Art E. Williamson
Director of Sanitary Engineering Services
Department of Health & Social Service
Cheyenne, Wyoming

PARTICIPANTS:

American Farm Bureau Federation
(by letter)

Sheldon G. Boone
Soil Conservation Service
U. S. Department of Agriculture
Denver, Colorado

John T. Maletic
Program Officer
Colorado River Water Quality Improvement Program
Bureau of Reclamation
Denver, Colorado

- - -

CONTENTS

Page

Opening Statement - Mr. Stein.................... 5

Letter from American Farm Bureau Federation...... 8

S. G. Boone...................................... 10

J. T. Maletic.................................... 14

General Discussion...............................140

Conclusions and Recommendations..................169

- - -

COLORADO RIVER ENFORCEMENT CONFERENCE

APRIL 26 - 27, 1972

REGISTRATION RECORD

T. John Baer, Jr.
State Representative, Mesa Co.
P. O. Box 28
Loma, Colorado 81524

Kenneth Balcomb
Counsel, Colo. River Conservation District
P. O. Drawer 790
Glenwood Springs, Colorado 81601

Tom Barker
Interstate Streams Engineer
State Engineer's Office
Cheyenne, Wyoming

Floyd A. Bishop, State Engineer
State Office Building
Cheyenne, Wyoming 82001

Sheldon G. Boone
USDA Representative
Western U. S. Water Plan
Soil Conservation Service
Federal Center
Denver, Colorado 80225

Fred L. Boydston
Water Resources Engineer
Colorado Water Conservation Board
1845 Sherman
Denver, Colorado 80203

Irwin L. Dickstein
Director, Enforcement Division
Environmental Protection Agency
1860 Lincoln Street
Denver, Colorado 80203

Dr. Robert A. Downs
Environmental Coordinator
Colorado Health Department
4210 East 11th Avenue
Denver, Colorado 80220

Donald P. Dubois
Deputy Regional Administrator
Environmental Protection Agency
1860 Lincoln Street
Denver, Colorado 80203

Carl Eardley
Deputy Assistant Administrator for Water Enforcement
Environmental Protection Agency
Washington, D. C. 20460

C. N. Feast
Newsletter Editor
Colorado Water Congress
1200 Lincoln
Denver, Colorado 80203

Robert W. Fischer
Denver Water Department
144 West Colfax
Denver, Colorado 80202

Roland C. Fischer
Engineer
Colorado River Water Cons. Dist.
Box 218
Glenwood Springs, Colorado 81601

Douglas W. Fraser
Attorney, New Mexico Environmental Improvement Agency
1843 Five Points Road, S. W.
Albuquerque, N.M.

Russell Freeman
Environmental Protection Agency
Enforcement Division
Region IX
San Francisco, California

Ralph E. Gonzales
Law Student
555 East 10th Avenue, Apt. 14
Denver, Colorado 80203

Ival V. Goslin
Executive Director
Upper Colorado River Commission
355 South 4th East Street
Salt Lake City, Utah 84111

Robert H. Hagen
Environmental Protection Agency
Region VIII
Denver, Colorado 80203

Sherman Hamilton
KBTV
1089 Bannock
Denver, Colorado

Thomas P. Harrison
Director, Enforcement Division
Environmental Protection Agency
1600 Patterson Street
Dallas, Texas

Myron Holbort
Chief Engineer
Colorado River Board of Calif.
217 West 1st Street
Los Angeles, Calif.

Norman B. Hume
Member, State Water Resources
Control Board
1416 Ninth Street
Sacramento, Calif. 95814

Nick C. Ioannides
Water Resource Engineer
Colorado Water Conservation Board
1845 Sherman
Denver, Colorado 80203

David Kennedy
Senior Engineer
Metropolitan Water District
1111 Sunset Boulevard
Los Angeles, Calif.

Andy Kurtz
Legislative Research
Colorado Farm Bureau
P.O. Box 5647
Denver, Colorado

H. Peter Larsen
Environmental Protection Agency
Region VIII
Denver, Colorado

T. J. Longlely
Water Resource Engineer
Colorado Water Conserv. Board
1845 Sherman
Denver, Colorado 80203

John T. Maletic
Program Officer
Colorado River Water Quality
Improvement Program
Bureau of Reclamation
Denver Federal Center
Denver, Colorado 80225

L. D. Morrill
Deputy Director
Colorado Water Conservation
Board
1845 Sherman
Denver, Colorado 80203

Martha M. Nicodemus
Environmental Protection Agency
Region VIII
Denver, Colorado

Richard O'Connell
Director, Enforcement Division
Environmental Protection Agency
Region IX
San Francisco, California

Kent Olsen
Assistant to the President
Atlas Minerals
910 Security Life Bldg.
Denver, Colorado

Donald E. Owen
3130 Shasta Way
California Dept. of Water
Resources
Sacramento, California

Donald L. Paff
Administrator
Colorado River Comm. of Nevada
P. O. Box 1748
Las Vegas, Nevada

REGISTRATION RECORD - COLORADO RIVER ENFORCEMENT CONFERENCE 4/26-27/72

W. Perry
Rocky Mountain News
Denver, Colorado

Rheta B. Piere
Administrative Officer, Enforcement
Environmental Protection Agency
Washington, D. C. 20460

John M. Rademacher
Technical Coordinator for
Enforcement—Water
Environmental Protection Agency
Washington, D. C. 20460

Dick O'Reilly
Reporter
Rocky Mountain News
400 West Colfax
Denver, Colorado

Frank J. Rozich
Director, Water Pollution Control
Division
Colorado State Health Department
4210 East 11th Avenue
Denver, Colorado 80220

Cathy Ruggiero
Enforcement Division
Environmental Protection Agency
Region VIII
Denver, Colorado

Carl L. Slingerland
Staff Engineer
New Mexico Interstate Stream
Comm.
State Capitol
Santa Fe, New Mexico 87501

Felix L. Sparks
Director
Colorado Water Conservation Board
1845 Sherman
Denver, Colorado 80203

C. C. Tabor
Chairman, Arizona Water Quality
Control Council
R 1, Box 19
Wellton, Arizona 85356

James R. Vincent
Chief, Review and Evaluation Branch
NFIC-D
Environmental Protection Agency
Denver, Colorado 80225

Art Williamson
Wyoming State Health Department
Cheyenne, Wyoming

Thomas R. Wolzien
News Reporter
KLZ TV
123 Speer Boulevard
Denver, Colorado 80217

Steve Wynkoop
Reporter
The Denver Post
Denver, Colorado

OPENING STATEMENT

BY

MR. MURRAY STEIN

MR. STEIN: Let's reconvene.

The State-Federal conference in the matter of pollution of the waters of the Colorado River and its tributaries is reconvened.

Due to the weather, the court reporter didn't arrive. I understand she is in Albuquerque. Several of the conferees didn't arrive. They are in various places, such as Salt Lake City and other delightful spots. We are going to try to see what we can do here.

Here is what we are going to try to do. Any papers that I have we will file with Mrs. Piere and we can get this back and get this added and printed in the record. So I think we can have at least a complete record of what we have.

I think we possibly should have a notation of how many conferees we have here, just for the record, to indicate the scope of the problem we have, because obviously before we come to an agreement we are going to have to clear with the other conferees.

Do you want to start, Art?

MR. WILLIAMSON: Art Williamson, from Wyoming, conferee.

MR. O'CONNELL: Richard O'Connell, EPA.

MR. DICKSTEIN: Irv Dickstein, EPA.

MR. ROZICH: Frank Rozich, Colorado.

MR. HUME: Norm Hume, California.

MR. STEIN: That means four of the seven States are not here. At least it's pretty close to a quorum if you count the Federal Government.

The suggestion is this. We know we have several people who wish to make statements. We also have, since the last conference and since we adjourned, asked the Bureau of Reclamation in the Department of the Interior to come up with some proposals, and I am very happy to say that the Department of the Interior did meet the deadline and has come up with a comprehensive and formidable proposal.

I would suggest that any people who have stated that they wish to make statements or that we have communications from, that we put these before the conferees. I just have one communication here which perhaps we might be able to read. Then we will hear from the Bureau of

Reclamation on its proposal. I think that has been submitted to the States. We do have a resolution which was submitted by the States last time and I think we might have some suggested conclusions and recommendations by the Federal conferees.

If we can pretty much get to agreement tonight, as I understand it, the States would be willing to try to reach the other conferees, the representatives of the other States by telephone, and then we can meet briefly tomorrow and we may be able, I think, to come to a complete agreement and wrap this up. Is this a correct understanding?

If it is, let us proceed. I think before we go into the material that the Federal conferees and the States have we should have the benefit of all the other people making representations. By the way, the Soil Conservation Service has a representative here too.

First I have a letter from the American Farm Bureau Federation, which says:

[illegible] 4/25/72

8

American Farm Bureau Federation

FARM BUREAU

WASHINGTON OFFICE
425 13TH STREET, N.W.
WASHINGTON, D. C. 20004
AREA CODE 202 - 638 - 6315
CABLE ADDRESS: AMFARMBUR

April 21, 1972

Mr. Murray Stein
Chief Enforcement Officer--Water
Environmental Protection Agency
Washington, D. C. 20460

Dear Mr. Stein:

The American Farm Bureau Federation with its 2,057,665 member families in 49 states and Puerto Rico appreciates this opportunity to present to the Environmental Protection Agency views relative to the mineral quality of the Colorado River.

Farm Bureau policy is to support and cooperate in the abatement of water pollution. Farm Bureau policies stress that plans for pollution control and abatement should be based on careful research and decisions made on factual information and constructive objectives.

The Colorado River salinity problem is complicated by many factors, including an international compact. In reviewing the river's record, we note that in the headwaters the total dissolved solid concentrates are about 50 mg/l or less. As the water moves downstream this salinity gradually increases until at Imperial Dam the long-term concentration from present development is at levels of about 865 mg/l. Much of this increasing salinity occurs as the result of natural erosion.

Salinity in the waters of the Colorado River is, of course, of long historic record. Observations recorded as early as 1903 show that irrigators became aware of some salinity increases resulting from use of water in agricultural production, and long before that natural sources had been observed as major sources of salinity.

Bureau of Reclamation studies show that the average annual salt output from irrigation will occur within a range of zero to two tons per irrigated acre in the Colorado River Basin.

Local irrigated areas overlying marine shales containing large quantities of soluble salts may have annual increases exceeding two tons per irrigated acre while areas covered with salt free loessial mangle overlying glacio fluvial deposits have practically no salt backup.

From the Bureau's report it is noted that there are in excess of 1.6 million acres in irrigation in the Upper Colorado Basin States and more than 1.3 million acres in irrigation in the Lower Colorado Basin States. In spite of all this development of Colorado River water use in agriculture production, the principle source of salinity pollution continues to be from natural sources. From available reports we note with interest that sources of salinity are 47 percent from natural sources and 37 percent from irrigation. Remaining percentages are from other sources.

We have had the opportunity to review portions of the report of Regions VIII and IX of the Environmental Protection Agency entitled "The Mineral Quality Problem in the Colorado River Basin," dated April 1971. We have found it helpful. The salinity problem has been the subject of numerous earlier reports, each making a contribution and each recognizing the very difficult problem of setting arbitrary standards. Mandating and allocating numerical salinity standards under current knowledge of feasibility and current financial capabilities, recognizing existing treaties and states rights to water development, are indeed complex problems.

We believe it is essential that studies underway, as well as planned studies, include feasibility studies, be pursued on point, diffuse, and irrigation sources to disclose the maximum improvement in water quality that can be achieved with present technology. Studies need to be completed that develop the costs involved, identify the control means, and specify the time required to achieve specific degrees of control for particular levels of the river.

From a base of facts which answer these unknowns, a comprehensive salinity control plan for the river can be produced. The plan must have engineering feasibility, political acceptability, and be administratively viable to the various institutions.

The American Farm Bureau, therefore, recommends that the Bureau of Reclamation, the Office of Saline Water, the Environmental Protection Agency, and other federal agencies, in cooperation with state water agencies, move forward as rapidly as possible to complete the necessary studies on the Colorado River to identify the sources of salinity pollution, the cost of control procedures, the time required to achieve controls, and the improvement in water quality which will accompany such control measures.

We further recommend that maximum attention be given to providing states and interstate groups opportunity to make inputs and cooperate to the fullest possible extent with federal agencies in the studies and in developing a comprehensive salinity control plan which will be workable as well as acceptable.

We think it is important to recognize that water quality may be degraded until control measures become operable.

We believe a numerical salinity standard should not be established until the control measures have been constructed and their operation proved practical.

We request that these views be made a part of the record of the Colorado River Basin Water Quality Project and the joint Federal-State Conference in the matter of the interstate waters of the Colorado River and its tributaries.

These views are expressed in cooperation with the member State Farm Bureaus of states that encompass the Colorado River Basin.

Sincerely,

Clifford G. McIntire

Clifford G. McIntire, Director
Natural Resources Department

MR. STEIN: This will be put in the record.

If there is no comment, I would like to call on Mr. Boone from the Department of Agriculture.

Mr. Boone.

SHELDON G. BOONE
SOIL CONSERVATION SERVICE
U. S. DEPARTMENT OF AGRICULTURE
DENVER, COLORADO

MR. BOONE: I am Sheldon Boone of the Soil Conservation Service, U. S. Department of Agriculture. I want to submit a supplemental statement of this Department here today.

> Following the conference on the Colorado River at Las Vegas, Nevada, on February 15-17, 1972, the U. S. Department of Agriculture has given further consideration to the Environmental Protection Agency report on the Mineral Quality Problem in the Colorado River Basin and to the opportunity to address this problem through programs of this Department. Because such a high proportion of the salt load of the

Colorado River is reported to come from lands devoted to irrigated agriculture, grazing and forest use, this Department is concerned with any programs which might be utilized to help reduce the salinity problem. Likewise, we believe that many of the programs of the Department can make valuable contributions in this effort.

We are presently examining the magnitude of our program inputs to make a more definitive appraisal of our present and potential contribution to physically reduce the salt load of the Colorado River system. As you know, this Department has been working with farmers and ranchers for many years to improve on-farm agricultural water management techniques. We anticipate that much of our on-farm activities will significantly complement the proposed Colorado River Improvement Program.

In addition the Department has undertaken to evaluate a number of programs relating to irrigation water management, erosion control and sediment delivery. It is anticipated that this evaluation would (1) show the relationship of erosion and sediment production to salt loading, (2) identify those lands which have the highest potential to affect salt loading through erosion and sedimentation, (3) identify watershed areas where management and treatment practices will reduce salt loading, (4) identify those areas in which improved irrigation system and management practices can be utilized, (5) show the relationship between such practices and salt loading, (6) quantify the effects which can be achieved through technical or financial assistance programs of the Department, and (7) identify the impacts of alternative salt load reduction programs on the agriculture, livestock and forest industries.

Many of these points will be considered through the Department's participation in the Western U. S. Water

Plan. However, more concerted effort and detailed investigation is needed. This Department is now considering ways to make these investigations in order to make a more definitive statement. When our plans for further action can be outlined in more detail, we will advise the chairman of this conference.

Thank you.

MR. STEIN: Thank you.

Are there any questions?

I have one general question. I believe I spoke to Mr. Loomis at the headquarters of Agriculture last week about other things. I wonder if there is any notion that you can give us of when we can expect to get further information from the Department of Agriculture?

MR. BOONE: I can't give you an exact date. I know we are working on it and will be working on it in the next few months, but I can't give you a date at this time.

MR. STEIN: You don't have any notion whether it is within a question of months that we are going to--

MR. BOONE: Well, I think it would be within a question of months, yes.

MR. STEIN: I tell you the reason I ask the question, and I don't know if this view is shared by most people, but I have been dealing with this problem for a long time, maybe almost a quarter of a century. At least I have come to the conclusion that perhaps the best way we are going to reduce salt in the Colorado River Basin is exactly through the program you are outlining here. I think there might be a limit to what the Bureau can do structurally or we can do. I think the agricultural processes and practices might be the clue to really controlling this problem.

MR. BOONE: Well, I think we would like to find out more about this possibility, right.

MR. STEIN: Thank you very much.

We will now hear from the Bureau of Reclamation, Department of the Interior, Mr. Maletic.

JOHN T. MALETIC, PROGRAM OFFICER
COLORADO RIVER WATER QUALITY IMPROVEMENT
PROGRAM, BUREAU OF RECLAMATION
DENVER, COLORADO

MR. MALETIC: Mr. Stein, conferees, ladies and gentlemen.

On behalf of the Bureau of Reclamation I am happy to introduce into the record the Bureau report on the Water Quality Improvement Program to the Colorado River.

MR. STEIN: Since this report is so important, this report will be entered into the record in its entirety without objection.

(Which said report follows:)

COLORADO RIVER
WATER QUALITY IMPROVEMENT PROGRAM

FEBRUARY 1972

UNITED STATES DEPARTMENT OF THE INTERIOR
Rogers C. B. Morton

BUREAU OF RECLAMATION
Ellis L. Armstrong

FOREWORD

The waters of the Colorado River are progressively increasing in salinity. A great concern over this situation and a need to implement a solution has been expressed by those who depend on this great river as a lifeline. This salinity control imperative extends to the Republic of Mexico and has become an important aspect in our international relations with that nation.

This report sets forth a plan of attack in the form of a comprehensive 10-year Water Quality Improvement Program. It identifies potential solutions both short and long range. Investigations are scheduled for control of salinity at point sources, diffuse sources, and irrigation sources. These investigations have been structured and integrated with programs involving desalting, weather modification, geothermal resources and basin-wide water resources management.

The objective of the program is to maintain salinity concentrations at or below levels presently found in the lower main stem of the Colorado River. In implementing this objective, the salinity problem will be treated as a basin-wide problem recognizing that salinity levels may rise until control measures are made effective while the upper basin continues to develop its compact apportioned waters.

The Bureau of Reclamation has statutory responsibility to study all possible means of improving the quality and alleviating the ill effects of water of poor quality in the Colorado River basin. This responsibility is provided for in three separate public laws authorizing the (1) Colorado River Storage Project and participating Projects, (2) Navajo Indian Irrigation Project and San Juan-Chama Project, and (3) Fryingpan-Arkansas Project.

TABLE OF CONTENTS

		Page
	Foreword	ii
	Summary	viii
I	Introduction	1
II	Previous Studies and Findings	12
	Water Resources of the Upper Colorado Basin-Basic Data (USGS)	13
	Upper Colorado River Basin Cooperative Salinity Control Study (USBR)	14
	Need for Controlling Salinity of the Colorado River (CRBC)	15
	Quality of Water-Colorado River Basin (USDI)	16
	Computer Simulation of the Hydrologic-Salinity Flow System Within the Upper Colorado River Basin (USU)	16
	Salinity of Surface Water in the Lower Colorado River-Salton Sea Area (USGS)	17
	The Mineral Quality Problem in the Colorado River Basin (EPA)	18
	Lower Colorado Region Comprehensive Framework Study (WRC)	20
	Upper Colorado Region Comprehensive Framework Study (WRC)	21
III	Program Objective	23
IV	Program Structure	25
	Departmental Responsibilities	26
	Organization	29
	Program Elements	30
	Program Costs	31
	Program Financing and Repayment	31
	Related Program Features	34
	Allied Programs	36
V	Effect of Program	37
VI	Description of Water Quality Improvement Program	49
	Basin-Wide Activities	50
	Mathematical Model for Colorado River	51
	Economics of Water Quality Management	53
	Institutional and Legal Analysis	54
	Ion Exchange Desalting	56

TABLE OF CONTENTS - Continued

Page

Irrigation Source Control 58

Irrigation Scheduling and Farm Management 58

Objectives 58
Program Evaluation 60
Proposed Areas 61

Water Systems Improvements and Managements 62

Grand Valley 63
Lower Gunnison 63
Uintah Basin 63
Colorado River Indian Reservation 64
Palo Verde Irrigation District 64

Point Source Control 64

LaVerkin Springs 65
Littlefield Springs 67
Blue Springs 67
Paradox Valley 68
Crystal Geyser 70
Glenwood-Dotsero Springs 71

Diffuse Source Control 72

Price River 72
San Rafael River 73
Dirty Devil River 74
McElmo Creek 74
Big Sandy River 75
Other Diffuse Sources Considered 75

VII Allied Programs 77

Western U.S. Water Plan 77
Desalting 78
Weather Modification 80
Geothermal Resources 82
Operation and Maintenance Activities 83
Water Quality Prediction Investigations 84
Research 87

LIST OF TABLES

Number		Page
1	Projected Program Reductions - Colorado River at Imperial Dam	xviii
2	Projected Concentrations of Total Dissolved Solids (mg/l) at Imperial Dam	9
3	Projects Depleting Colorado River Water	11
4	Potential Effects and Costs - Point and Diffuse Source Control Projects	40
5	Potential Effects and Costs - Irrigation Scheduling and Management and Water Systems Improvement Projects	41
6	Projected Program Reductions - Colorado River at Imperial Dam	45

LIST OF FIGURES

Number		Page
1	Geochemical Cycle of Surface and Ground Water	3
2	Colorado River Water Quality Improvement Program	32
3	Location of Salinity Improvement Projects-Colorado River Basin	33
4	Runoff Producing Areas - Upper Colorado River Basin	81
5	Hydrologic System for Simulation Submodel	86

SUMMARY

The Situation

Waters of the Colorado River are becoming more saline. Great concern and a sense of urgency to halt the rise have been expressed by those who depend upon the river as a lifeline. The salinity control imperative extends to the Republic of Mexico and has become an important aspect in our international relations with that nation.

At the headwaters the average salinity 1/ (concentration of total dissolved solids) in the Colorado River is less than 50 mg/l and progressively increases downstream until, at Imperial Dam, the present modified 2/ condition is 865 mg/l. Projections of future salinity levels without a control program suggest that values of 1,250 mg/l or more will occur at Imperial Dam by the year 2000. One projection used in the Lower Colorado Region Comprehensive Framework Study 3/ foresees such a level being reached by 1980. Should these increases

---

1/ Salinity as used in this report refers to the concentration of total dissolved solids and is reported in milligrams per liter (mg/l). This unit of concentration is nearly equivalent to parts per million (ppm) up to concentrations of 7,000 mg/l.

2/ Present modified refers to the historic conditions (1941-1968) modified to reflect all upstream existing projects in operation for the full period.

3/ Water Resources Council.

in salinity levels occur, the agriculture in the Imperial, Coachella, Gila, and Yuma Valleys would be further threatened. Also, a poorer water quality would be diverted to the Metropolitan Water District of Southern California and the Las Vegas Valley Water District, causing further economic losses to the very large block of domestic water users in California and Nevada. Upon completion of the Central Arizona Project, water users in the Phoenix and Tucson areas would be similarly affected.

The Proposed Solution

General Approach and Authority

A comprehensive 10-year Water Quality Improvement Program has been structured and integrated with programs involving weather modification, geothermal resources, desalting, and the Western U.S. Water Plan. These programs, when implemented, could maintain salinity in the lower main stem at or below present levels.

The Water Quality Improvement Program has an investigation and an implementation phase. The authority for the investigation is derived from Public Laws 84-485, 87-483, and 87-590 relating to the Colorado River Storage Project and Participating Projects, Navajo Indian Irrigation Project and San Juan-Chama Project Act, and the Fryingpan-Arkansas Project Act, respectively.

Feasibility studies would be initially performed on a total of 16 irrigation, point, and diffuse salinity sources with related basin-wide planning involving development of a mathematical model of the Colorado River, economic analysis of water quality, analysis of legal and institutional matters, and the investigation of potentials for improving water quality at points of diversion.

Early emphasis is being placed on those activities most likely to achieve water quality improvement at least cost. Construction of a mathematical model may reveal better ways to operate the river system to generate water quality benefits without incurring capital investment costs for structural control measures. Irrigation source control, involving close integration of on-farm irrigation water scheduling and management, with water systems improvement and management, is expected to significantly reduce salt loadings. Some measuring devices may be required to implement the irrigation scheduling and management program which is now being implemented. This can be expected to achieve early benefits at minimal cost.

Following the full operational establishment of the irrigation scheduling activity, water users would be expected to operate the program. This could be contractually tied to water systems improvements and the related cost-sharing arrangements with the irrigation districts or other entities involved. The irrigation scheduling and water systems improvement activities need to move together along with parallel improvements of on-farm irrigation systems, the latter to be done primarily through private investment with technical assistance from the Soil Conservation Service and some financial aid from the Rural Environmental Assistance Program.

Program Elements

The specific Water Quality Improvement Program elements and the fiscal years during which the work is presently scheduled to be accomplished are as follows:

Mathematical simulation submodel, 1972-1973

Economic evaluation of water quality, 1972-1976

Institutional and legal analysis, 1972-1973

Ion exchange process systems, 1972-1974

Irrigation scheduling and management, 1972-1979 (Grand Valley Basin, 1972-1978; Lower Gunnison Basin, 1974-1979; Uintah Basin, 1974-1978; Colorado River Indian Reservation, 1974-1978; Palo Verde Irrigation District, 1974-1978)

Water systems improvement and management, 1972-1976 (Grand Valley Basin, 1972-1975; Lower Gunnison Basin, 1973-1976; Uintah Basin, 1974-1976; Colorado River Indian Reservation, 1972-1974; Palo Verde Irrigation District, 1974-1976)

Point source control projects, 1972-1978 (LaVerkin Springs, 1972-1973; Paradox Valley, 1972-1975; Crystal Geyser, 1972-1973; Glenwood-Dotsero Springs, 1972-1976; Blue Springs, 1973-1978; Littlefield Springs, 1974-1975)

Diffuse source control projects, 1974-1977 (Price River, 1974-1977; San Rafael River, 1975-1977; Dirty Devil River, 1976-1978; McElmo Creek, 1976-1978; Big Sandy River, 1974-1978)

Very little basic data are available regarding the control of diffuse sources. Beginning in fiscal year 1972 basic data will be collected on these sources.

These investigations and the implementation of the irrigation scheduling and management work would cost about $18 million over the 10-year period. Of this amount, $395,000 is currently being used to initiate the program, increasing to $1,005,000 in fiscal year 1973.

Allied Programs

Important allied programs include weather modification, desalting, geothermal resources, research, and the Western U.S. Water Plan. Weather modification research now underway is expected to develop, by 1980, a reliable and workable system for increasing precipitation. The Upper Colorado River Basin will be one of the first areas where region-wide applications could be made. It is estimated that up to 2 million acre-feet of new water could be added to the river system. This would serve to significantly improve the salinity levels.

Desalting will initially involve the installation of a research and development prototype facility using the reverse osmosis process. The prototype plant would have a capacity of 15 mgd and could be expanded to 150 mgd. The facility would be located in the lower reach of the river. If expanded to a capacity of about 150 mgd, the salinity levels in the lower reach would be greatly improved. This would be a cooperative effort between the Office of Saline Water and the Bureau of Reclamation.

Geothermal investigations are now being conducted by the Bureau of Reclamation and the Office of Saline Water. These investigations could ultimately lead to additional sources of water. This water could be fitted into the overall river basin management plan to achieve further improvements in water quality.

Research is underway or scheduled which would provide valuable inputs to the salinity control effort. Included is such work as developing better predictions of irrigation return flow quality, deriving the systems for assessing ecologic impacts of water resource projects, developing procedures for management and use of saline water, testing advanced irrigation systems, and identifying waste-water reclamation opportunities.

It will be the responsibility of the Westwide Study to present the varied and complex alternatives for development, regulation, and use of all waters of the Colorado River Basin, examine tradeoffs between alternatives, prepare plans and cost estimates, and recommend priority of future studies and development. Close coordination and cooperation will be maintained between the Colorado River Water Quality Improvement Program and the Westwide Study to assure the preparation of a sound, well integrated plan of development for the Colorado River Basin.

The Organization

The many activities involved will require close coordination of the work with Federal, State, and local agencies and private and public groups having a mutual concern and interest in the program. Overall responsibility for the program has been assigned to the Bureau of Reclamation. Within this agency, immediate responsibility for direction has been given to the Assistant Commissioner - Resource Planning, with strong coordinative ties with the Assistant Commissioner - Resource Management. Field planning, construction, and operation activities will be handled by the Regional Directors, Regions 3 and 4, with technical assistance as needed being provided by the Engineering and Research Center. A new division is being established at the E&R Center as a focal point for the program to serve the multifaceted coordination and leadership activities involved.

The Implementation

Assuming all projects now under investigation or scheduled to be investigated are implemented, the program is expected to involve capital expenditures in the order of magnitude of $400 to $500 million. These costs are to be shared with the beneficiaries. Therefore, an essential feature of the feasibility studies and the related basin-wide studies will be to develop equitable cost sharing and repayment formulas. New institutional arrangements may be required not only as related to cost sharing and repayment, but also to the operation and maintenance of the constructed facilities. The urgency of the salinity conditions in the lower reach makes it imperative that movement from the study to the construction phase be expedited. This could be done for individual projects within a period of 1 to 2 years following completion of a favorable finding of feasibility. In the interim, as previously stated, some salinity improvements can be anticipated through alteration of river operations using the mathematical model and from the irrigation scheduling and management activities.

Construction of the water system improvement projects would involve periods of 4 to 5 years. Most of this work could be completed by fiscal year 1981. Of the point source control projects, LaVerkin Springs, Crystal Geyser, Littlefield Springs, and Paradox Valley could be constructed in a period of 3 to 4 years. On this basis, construction could be completed during fiscal year 1980. Blue Springs and Glenwood-Dotsero Springs will involve consideration of many complex factors regarding the engineering plan and related environmental and social considerations. Construction, even if found feasible in all respects, could not be started before 1978 on Glenwood-Dotsero Springs and 1980 on Blue Springs. The lack of data on the diffuse source control projects could delay construction starts until fiscal year 1979 or later.

The Effects of Programs

The average annual salinity concentration of the Colorado River at Imperial Dam during the period 1941 to 1968 (most recently published data) was 751 mg/l. The annual salinity concentrations during this same period have ranged from a minimum of 649 mg/l in 1949 to a maximum of 918 mg/l in 1956. The monthly salinity concentrations of the Colorado River at Imperial Dam during the period 1941 to 1968 have experienced an even wider range from a minimum of 551 mg/l in December 1952 to a maximum of 1,000 mg/l in January 1957.

Levels of salinity concentrations presently found in the lower Colorado River vary depending on the type period used to describe the level. As indicated above, the average for a year is greater than the level during the period 1941 to 1968 and the peak monthly concentration is even greater than the level for a year.

To depict effects of the Water Quality Improvement and Allied Programs, Table 1 was developed showing the projected reductions in salinity concentrations for each program and the estimated effects on the synthesized salinity levels at Imperial Dam.

The values in the table are initial estimates based on the average hydrologic conditions for the period of record 1941-1968.

The 1970 average annual value of 865 mg/l has been derived on the assumption that present developments in the basin were completed and operating during the period of record. In other words, the effects on water quality of all present developments have been extended back to 1941 from the time they became operational.

Similarly, the average annual values for the years 1980, 1990, and 2000 were synthesized to reflect the influence on water quality during the period of record of water resource developments expected to

Table 1

PROJECTED PROGRAM REDUCTIONS - COLORADO RIVER AT IMPERIAL DAM
(Average annual values in mg/l - 1941-1968 period of record)

	1970	1980	1990	2000
Estimated Salinity Level (Full development - no control program)	865	1000	1200	1250
Range	(750-1060)	(860-1220)	(1040-1470)	(1080-1530)
Projected Program Reductions				
Water Quality Improvement Program	(-)	(-60)	(-160)	(-160)
Allied Programs	(-)	(-60)	(-195)	(-245)
Total Program Reduction	-	-120	-355	-405
Estimated Salinity Level (Full development with control programs)	865	880	845	845
Range	(750-1060)	(740-1100)	(685-1115)	(675-1125)

be completed by those dates. These estimates must be regarded as initial approximations. The feasibility and related studies, buttressed by additional research, will improve reliability of the estimates.

It should be recognized that the values in the table are computed average annual values at Imperial Dam under the stated assumptions. The average annual modified value for 1970 of 865 mg/l based on the 1941 to 1968 period would probably have ranged from an annual minimum of 750 mg/l to an annual maximum of 1,060 mg/l. However, with Lakes Powell and Mead regulating the Colorado River, it would require several consecutive low-flow years to produce an annual salinity concentration of 1,000 mg/l, or higher, at Imperial Dam.

Historically, records at Imperial Dam show that the average salinity concentration for January 1957 was 1,000 mg/l and for December 1967 it was 992 mg/l. Six other months in the period 1941-1968 have had average concentrations above 960 mg/l. However, with present development, it is probable that the average monthly concentrations for these 8 months would have exceeded 1,000 mg/l. Furthermore, with present developments, the 1,000 mg/l mean monthly concentration at Imperial Dam would have been exceeded in 40 months during the period 1941-1968.

It is not possible to predict future salinity concentrations for any particular month, nor can it be assumed that past flow and concentration cycles will be repeated in the future.

It is premature to define numerical standards of salinity levels at Imperial Dam now or in the next 2 or 3 years. It is essential that the available technical knowledge of the physical and social factors involved and their interrelationships and the probable consequences of proposed changes be fully understood before applying numerical standards.

Program Appraisals

Appraisal of program progress and direction will be made at intervals of 2 years. The factors to be considered include: (1) kinds of physical control works needed, (2) economic viability of proposed control works, (3) public acceptance and commitment to the proposals, (4) potential impacts of evolving technology, and (5) relationships within the basin-wide management plan.

I INTRODUCTION

The waters of the Colorado River system serve millions of people in many ways. It is a vital link in sustaining cities and farms, mines and industry, recreational space and wildlife, and areas of great aesthetic value to the Nation. The water is used for irrigating crops, producing energy, providing recreation, sustaining cattle and wildlife, supporting industry, and supplying the common daily needs of people for drinking, washing, bathing, cleaning, heating, cooling, watering lawns and gardens, protecting property, and removing wastes. These many uses place varying demands not only on the quantity but also on the quality of water. In the Colorado River, quantity and quality are inseparable. Tomorrow's needs are to be met by augmenting quantity and improving quality. The latter is the concern of this report and is to be regarded as an integrated facet of an overall comprehensive basin management plan for use and development of the water resources.

At its headwaters, the Colorado River has a total dissolved solids concentration of 50 mg/l 1/ or less. As the water moves downstream through this vast arid region, there is a gradual increase in salinity

---

1/ Refers to milligrams per liter. This unit is nearly equivalent to parts per million (ppm) up to concentrations of 7,000 mg/l.

to the Imperial Dam. Here the present modified 2/ average concentration is 865 mg/l. This increase arises as a result of both natural processes and the activities of man. Wherever rain falls, natural solute erosion occurs. This process embraces the geochemical reactions that take place as water moves through the hydrologic cycle. The pathways and some of the important reactions involved in this cycle are depicted in Figure 1. The process has been active over geologic time. Even with the extensive developments by man, the natural processes are still the principal source of salinity in the Colorado River.

While the geochemical processes add a large variety of dissolved matter to the water, only 10 elements make up 99 percent or so of the dissolved constituents. These are hydrogen, sodium, magnesium, potassium, calcium, silicon, chlorine, oxygen, carbon, and sulfur. The elements occur in solution as various ions, molecules, or radicals. The major part of the dissolved constituents in the Colorado River are made up of the cations calcium, magnesium, and sodium, and the anions sulfate, chloride, and bicarbonate. These, plus minor amounts of other dissolved constituents, are commonly referred to as salinity.

2/ Present modified refers to the historic conditions (1941-1968) modified to reflect all upstream existing projects in operation for the full period.

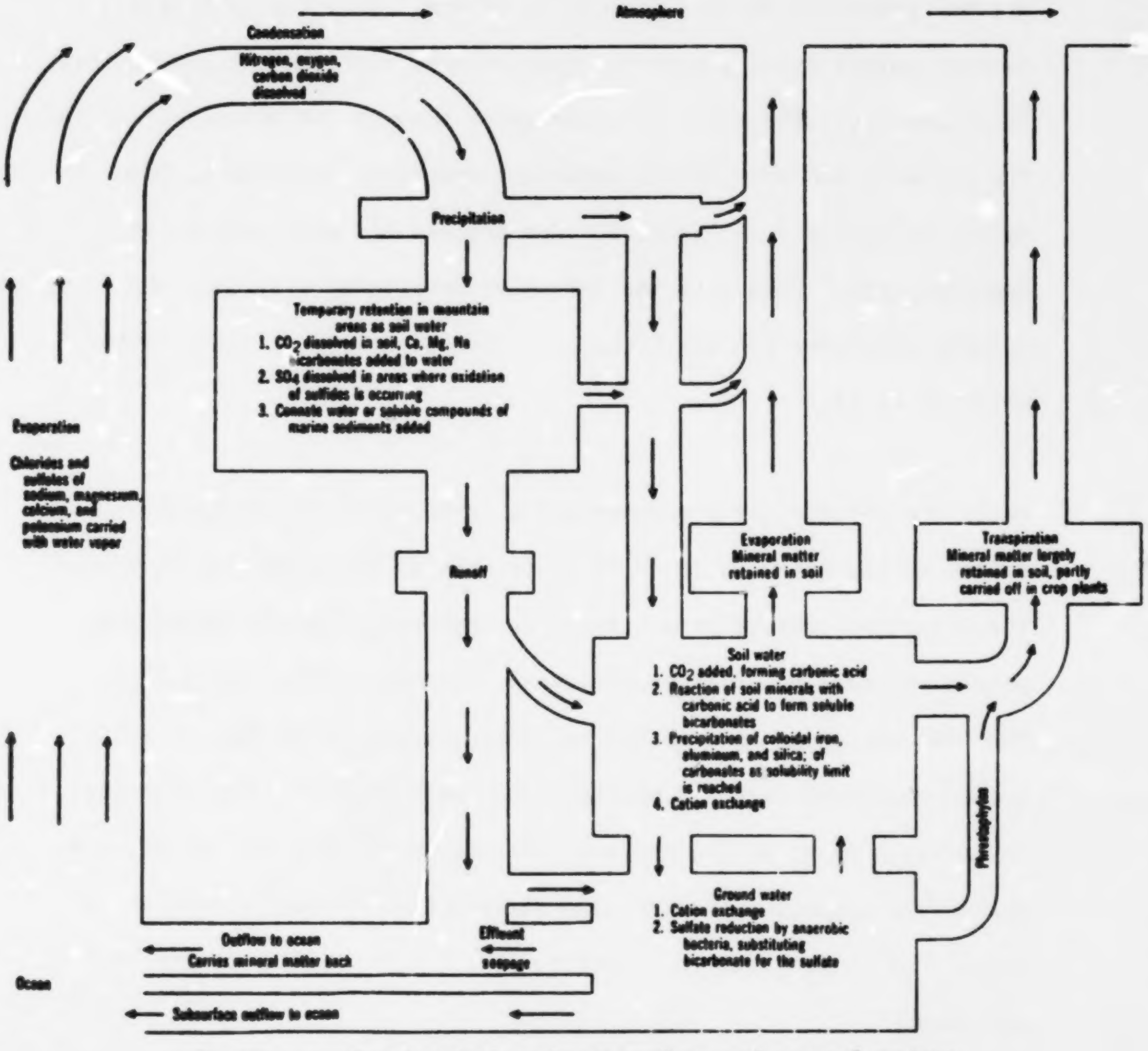

Atmosphere
Condensation
Nitrogen, oxygen, carbon dioxide dissolved
Precipitation
Temporary retention in mountain areas as soil water
1. CO_2 dissolved in soil, Ca, Mg, Na bicarbonates added to water
2. SO_4 dissolved in areas where oxidation of sulfides is occurring
3. Connate water or soluble compounds of marine sediments added
Evaporation
Chlorides and sulfates of sodium, magnesium, calcium, and potassium carried with water vapor
Runoff
Evaporation
Mineral matter retained in soil
Transpiration
Mineral matter largely retained in soil, partly carried off in crop plants
Soil water
1. CO_2 added, forming carbonic acid
2. Reaction of soil minerals with carbonic acid to form soluble bicarbonates
3. Precipitation of colloidal iron, aluminum, and silica; of carbonates as solubility limit is reached
4. Cation exchange
Phreatophytes
Ground water
1. Cation exchange
2. Sulfate reduction by anaerobic bacteria, substituting bicarbonate for the sulfate
Outflow to ocean
Carries mineral matter back
Effluent seepage
Ocean
Subsurface outflow to ocean

FIGURE 1 –Geochemical cycle of surface and ground waters.

Development of the water resources in the Colorado River Basin took place gradually from the beginning of settlement around 1860 and has been continuing. In the Upper Basin, 1.4 million acres were irrigated by 1920. The pace of development slowed thereafter with the result that in 1965, 1.6 million acres were under irrigation. In addition, the water exported from the Upper Basin amounted to about 500,000 acre-feet per year and consumptive use of water for municipal and industrial purposes depleted about 30,000 acre-feet per year.

Initial development in the Lower Basin was slow because of difficult diversions from the Colorado River and its widely fluctuating flow. However, with the completion of the Boulder Canyon Project in the 1930's, the development accelerated and about 1.3 million acres are now under irrigation. In this regard, the Colorado River now provides 75 percent of the water to southern California where more than half of that State's 20 million people live.

The importance of salinity in water supplies was recognized as early as 1903. At that time, the initial work was done to identify desirable salinity levels for maintenance of crop production under irrigation. A limited amount of water sampling and analysis of the river was being performed, primarily by the Geological Survey. The main purpose of these early tests was to evaluate the suitability of the water supply for irrigation and other uses. In time, it became clear that a gradual rise in the salinity of the river was occurring as the water resources were developed.

Salt-concentrating effects were produced by evaporation, transpiration, and diversion of high quality water out of the basin. Also, salt-loading effects occurred through the addition of dissolved solids to the river system from both natural and manmade sources. Because of the wide fluctuations in concentration from natural causes, the developments on the river, particularly the large reservoirs, produced offsetting beneficial effects by minimizing these fluctuations.

Prior to their authorization, it was known that the Colorado River Storage and Participating Projects, Navajo Indian Irrigation Project, San Juan-Chama Project, and the Fryingpan-Arkansas Project would cause significant increases in salinity levels. This was expected to arise primarily from the increased consumptive use of water and transport of high quality water out of the basin. Recognizing the concern of the Colorado River water users, Congress stipulated that studies be made of the water quality in the basin and that control plans be developed. The stipulation was expressed in the authorizing legislation for the projects.

As a result of the legislative requirements, a basic network of water quality stations was established at principal points throughout the Colorado River Basin. Analyses and studies were begun for the entire basin, biennial reports were started in 1963 and have continued since that time. These reports cover the basic studies and evaluations of salinity conditions, the anticipated effects of additional developments, the effect of salinity on water use, the potentials for salinity control, and other related water quality aspects.

The Colorado River Basin Water Quality Control Project was established in 1960 by the U.S. Public Health Service. These functions were later transferred to the Federal Water Quality Administration within the Department of the Interior and, subsequently, transferred to the Environmental Protection Agency. The early project investigations assisted in better defining the water quality conditions of the basin. In 1963, efforts were directed towards evaluating various salinity problems.

In 1968, the FWQA and the Bureau of Reclamation initiated a joint reconnaissance salinity control study in the Upper Basin to identify potential controllable sources of salinity, make preliminary assessments of the technical feasibility of the control measures, and derive initial cost estimates for installation and operation of such measures. The first year of the study was financed by the FWQA, which transferred funds to the Bureau of Reclamation, and the second year of work was financed by the Bureau. Upon completion of the reconnaissance studies, FWQA proposed to finance feasibility studies; however, budget restrictions in fiscal year 1970 prevented funding the studies.

Also in 1968, the two agencies cooperated to develop a proposed salinity control plan of study for the Colorado River Basin. This initial program had an investigation phase spread over a 6-year period, with costs averaging about $1.75 million annually. The second phase was to involve implementation of a basin-wide salinity control plan. During the Federal reorganization activities which transferred the responsibilities of FWQA of the Department to the newly established Environmental Protection Agency, the program became inactive.

Subsequently, the Colorado River Board of California prepared and issued a report in 1970 entitled "Need for Controlling the Salinity of the Colorado River." The EPA also completed a report on the mineral water quality. The report, entitled "The Mineral Quality Problems in the Colorado River Basin," was completed in 1971 and pulled together the studies made during the period 1963-1970.

Under the direction of the Water Resources Council, a State-Federal interagency group prepared a framework program for the development and management of the water and related land resources of the Upper and Lower Colorado Region. These reports, abstracted in the next section of this report, recommended continuing studies of the Region's increasingly complex water quality issues and suggested various salinity control measures. Concurrently, the Bureau of Reclamation, with the assistance of the several States involved, developed the program described herein for controlling the salinity of the river. The recommendations contained in the reports of the various organizations were considered in developing this program.

The progress reports by the Bureau of Reclamation, the salinity report by the Colorado River Board of California, the Upper and Lower Colorado Region Comprehensive Framework Studies of the Water Resources Council, and the EPA report, have served to identify and better define the issues involved. The important fact emerging is that salinity is projected to increase unless a comprehensive, basin-wide water quality management plan is implemented and supported by the installation of structural and nonstructural measures to control salinity increases. Projected estimates of salinity levels at Imperial Dam are presented in Table 2. The projected salinity levels in all studies are considerably above the present modified average concentration of 865 mg/l.

TABLE 2

Projected Concentrations of Total Dissolved Solids
(mg/l) at Imperial Dam
(Average values)

	Year					
Source	1980	1990	2000	2010	2020	2030
EPA	1,060	-	-	1,220	-	-
CRBC	1,070	-	1,340	-	-	1,390
WRC	1,260	-	1,290	-	1,350	-
USBR	1,000	1,200	1,250	-	-	-

EPA: Environmental Protection Agency

CRBC: Colorado River Board of California

WRC: Lower Colorado Region Comprehensive Framework Study (Water Resources Council)

USBR: Bureau of Reclamation

The differences in the values reported by the various agencies arise from assumptions made regarding completion dates for water development projects, estimates of the amount of salt loading or concentration effects produced by these projects, the period of analysis used, and estimates of the time involved for the effects to emerge in the lower reach. The USBR projection is based on progressive accomplishment of the projects listed in Table 3 with completion assumed to occur by the year 2000.

It is significant that all studies by the various agencies predicted that proposed developments will cause a considerable increase in the future salinity of the river. Even under current salinity conditions, some irrigators are resorting to special practices in using the water to grow salt-sensitive crops. Some areas have drainage conditions which could be magnified if higher salinity water were used. Municipal and industrial users are faced with considerable expense in treating water. It is clear that allowing the salinity of the river to increase will result in considerable additional economic injury.

Table 3

Projects depleting Colorado River water

Project and state	New depletion (ac.-ft.)	New irrigation land (acres)
Above the gage Green River at Green River, Wyoming		
Seedskadee, Wyoming	145,000	58,000
Westvaco and others, Wyoming	86,000	1/
Between the above gage and the gage Green River near Greendale, Utah		
Lyman, Wyoming	10,000	0
Utah Power & Light and others, Wyoming	8,000	1/
Above the gage Duchesne River near Randlett, Utah		
Central Utah Project, Utah		
Bonneville Unit	166,000	2/
Upalco Unit	10,000	0
Uintah Unit	30,000	7,800
Between the gages Green River near Greendale, Utah, and Duchesne River near Randlett, Utah, and the gage Green River at Green River, Utah		
Four County, Colorado	40,000	2/
Hayden Steamplant, Colorado	12,000	1/
Cheyenne-Laramie, Wyoming	24,000	2/
Savery-Pot Hook, Colorado-Wyoming	27,000	17,920
Central Utah Project		
Jensen Unit	15,000	449
Above the gage San Rafael near Green River, Utah		
Utah Power & Light, Emery County, Utah	5,000	1/
Above the gage Colorado River near Glenwood Springs, Colorado		
Denver-Englewood, Colorado	216,000	2/
Green Mountain M&I, Colorado	12,000	1/
Homestake Project, Colorado	49,000	2/
Between the above gage and gage Colorado River near Cameo, Colorado		
Independence Pass Expansion, Colorado	14,000	2/
Fryingpan-Arkansas, Colorado	70,000	2/
Ruedi M&I, Colorado	38,000	1/
West Divide, Colorado	76,000	19,000
Above the gage Gunnison River near Grand Junction, Colorado		
Fruitland Mesa, Colorado	28,000	15,870
Bostwick Park, Colorado	4,000	1,610
Dallas Creek, Colorado	37,000	15,000
Between the gages Colorado River near Cameo, Colorado, and Gunnison River near Grand Junction, Colorado, and the gage Colorado River near Cisco, Utah		
Dolores, Colorado	3/140,000	32,000
San Miguel, Colorado	85,000	26,000
Above the gage San Juan River near Archuleta, New Mexico		
San Juan-Chama, New Mexico	110,000	2/
Navajo Indian Irrigation, New Mexico	4/508,000	110,000
Between the above gage and the gage San Juan River near Bluff, Utah		
Animas-La Plata, Colorado-New Mexico	146,000	46,500
Expansion Hogback, New Mexico	10,000	0
Utah Construction Co., New Mexico	25,000	1/
Return flow--Dolores and Navajo Indian Irrigation, Colorado and New Mexico	-311,000	3/ 4/
Between the gages Green River at Green River, Utah; San Rafael River near Green River, Utah; Colorado River near Cisco, Utah; and San Juan River near Bluff, Utah; and the gage Colorado River at Lees Ferry, Arizona		
Resources, Inc., Utah	102,000	1/
Arizona M&I, Arizona	35,000	1/
Salvage	-80,000	
Subtotal Upper Basin	1,892,000	350,140
Between the above gage and the gage Colorado River near Grand Canyon, Arizona	0	0
Above the gage Virgin River at Littlefield, Arizona		
Dixie Project, Utah	5/48,000	6,900
Between the gages Colorado River near Grand Canyon, Arizona, and Virgin River at Littlefield, Arizona, and the gage Colorado River below Hoover Dam, Arizona-Nevada		
Southern Nevada Water Project, Nevada	6/240,000	1/
Between the above gage and the gage Colorado River below Parker Dam, Arizona-California		
Fort Mohave and Chemehuevi Indian, Arizona, California, and Nevada	83,000	20,900
Central Arizona, Arizona7/	433,000	
Reduced Metropolitan Water District Diversions7/	-433,000	
Kingman, Arizona	18,000	1/
Mohave Valley I&D District, Arizona	6,000	1/
Lake Havasu I&D District, Arizona	7,000	1/
Salvage	-87,000	
Reduced Metropolitan Water District Diversions7/	-199,000	
Between the above gage and the gage Colorado River at Imperial Dam, Arizona-Colorado		
Colorado River Indian, Arizona-California	243,000	60,840
Salvage	-104,000	
Subtotal Lower Basin	255,000	88,640
Total Colorado River	2,147,000	438,780

1/ In-basin depletion without irrigated lands.

2/ Transmountain diversion.

3/ In-basin transfer from Dolores River drainage to the San Juan River drainage--estimated 53,000-acre-foot return flow to the San Juan River.

4/ Diversions at Navajo Reservoir, estimated 258,000-acre-foot return flow to the San Juan River below the gage near Archuleta, New Mexico.

5/ Includes a transmountain diversion to Great Basin.

6/ Pending full development, the Mohave Thermal Plant will use part of this water which will be diverted below Hoover Dam.

7/ The Central Arizona Project diversions will vary, depending on the depletions by other projects on the river. Under present modified conditions maximum diversions to Central Arizona could be 2,172,000 acre-feet but with full depletions by the projects tabulated, the maximum diversions would be 433,000 acre-feet. Also with full depletions by the projects tabulated, the diversions to the Metropolitan Water District of Southern California would be reduced to an annual 550,000 acre-feet from its present diversions of 1,182,000 acre-feet. This will provide 199,000 acre-feet needed to develop the other tabulated projects in the Lower Basin in addition to the 433,000 acre-feet delivered to the Central Arizona Project.

analysis used, and estimates of the time involved for the effects to emerge in the lower reach. The USBR projection is based on progressive accomplishment of the projects listed in Table 3 with completion assumed to occur by the year 2000.

It is significant that all studies by the various agencies predicted that proposed developments will cause a considerable increase in the future salinity of the river. Even under current salinity conditions, some irrigators are resorting to special practices in using the water to grow salt-sensitive crops. Some areas have drainage conditions which could be magnified if higher salinity water were used. Municipal and industrial users are faced with considerable expense in treating water. It is clear that allowing the salinity of the river to increase will result in considerable additional economic injury.

II PREVIOUS STUDIES AND FINDINGS

The program for controlling salinity in the Colorado River has evolved from prior studies. Those of most relevance to the program were performed by the U.S. Geological Survey, Bureau of Reclamation, Environmental Protection Agency (and its predecessor agencies), Water Resources Council, Colorado River Board of California, and Utah State University.

The USGS studies were of the definition type. They trace historic salinity levels, estimate salt loading from specific sources, and identify salt contribution from various river reaches. The Bureau of Reclamation studies report on the past, present modified, and future water quality conditions in the basin. The effects of salinity on water uses and potentials for salinity control are discussed. The EPA study describes salinity conditions in the basin, evaluates the nature and magnitude of damages to water users, examines alternative salinity control measures, and provides recommended measures and programs for control of the salinity levels. The Colorado River Board of California also defined the nature and magnitude of the problem and presented a plan for controlling the salinity at or near present levels. The Water Resources Council Task Forces drew heavily on the prior studies and developed estimates of future salinity conditions and identified potential control measures. Utah State University performed a computer simulation of the hydrologic-salinity flow system in the Upper Basin.

Differences in findings among the various studies occurred, particularly as related to quantitative displays of historic salinity conditions, salt loading, concentrating effects, contributions from various sources, and economic impacts. Because there was nonuniformity in assumptions, data sets, and procedures, the quantitative findings should be expected to differ. On the other hand, the conclusions derived are generally similar. The major sources of salinity were identified as arising from natural point and diffuse sources, irrigation, evaporation, out-of-basin transfers, and municipal and industrial uses. The largest portion of the mineral burden was found to originate in the Upper Basin. The natural sources were thought to be the major contributors to the salt loading. Salinity was projected to continually increase in the lower reaches unless control programs are implemented. The impact of the increasing salinity levels was found to be primarily economic. While salinity levels increased over time, the composition of the water with respect to individual ions remained relatively stable.

Water Resources of the Upper Colorado Basin-Basic Data (USGS)

In 1964, the U.S. Geological Survey published its report entitled "Water Resources of the Upper Colorado Basin-Basic Data" as

Professional Paper 442. This report is based on data for the 1941-1957 period. In summary, the report states that if the developments of 1957 had not been in existence then: (1) the hypothetical average yearly water yield at Lees Ferry would have been about 15.2 million acre-feet rather than the 12.7 million measured, (2) the hypothetical average concentration would have been about 250 mg/l rather than observed values of about 500 mg/l, and (3) the hypothetical dissolved solids discharge would have been about 5.2 rather than observed amounts of about 8.7 million tons annually. Substantially all the increase in dissolved solids discharge was construed by the investigators to be an effect of irrigation on 1.4 million acres of land. They estimated the average increase to be 2.4 tons per irrigated acre per year. From one part of the area to another, this average was said to range from about 0.1 to 5.6 tons. The report did not indicate which portion of this increase was due specifically to irrigation and which to natural sources.

Upper Colorado River Basin Cooperative Salinity Control Study (USBR)

In cooperation with the Federal Water Pollution Control Administration (now the Office of Water Programs, Environmental Protection Agency), the Bureau of Reclamation in July 1969 completed a report entitled "Upper Colorado River Basin Cooperative Salinity Control

Study." The report is currently under review by EPA and has not yet been released. It deals with the control of salinity from specific identified sources, appraises potential salt-load reduction values, and evaluates status of the economic feasibility of salinity control. The need for a coordinated salinity control program for the entire Colorado River is stressed.

Need for Controlling Salinity of the Colorado River (CRBC)

The Colorado River Board of California published a report entitled "Need for Controlling Salinity of the Colorado River" in August 1970. Using available data, the report traces the average salinity principally at Hoover, Parker, and Imperial Dams and makes projections for the years 1980, 2000, and 2030. The historical average is based on the years 1963-1967 and shows values below Hoover Dam to be 730 mg/l and at Imperial Dam 850 mg/l. Below Hoover Dam, values of 830 and 1,090 mg/l are projected for the years 1980 and 2030, respectively. Comparable projections for Imperial Dam suggest 1,070 mg/l in 1980 and 1,390 mg/l in 2030. The salinity is estimated to cause $8 to $10 million damage annually for each salinity increase of 100 mg/l. The report identifies a number of potential salinity control projects which, if constructed, might serve to maintain salinity near present levels.

Quality of Water - Colorado River Basin (USDI)

Biennial Progress Reports on the "Quality of Water - Colorado River Basin" are prepared by the Department of the Interior. The initial report was issued in 1963 and the latest report is dated 1971. The report displays the past, present modified, and estimated future quality of the Colorado River at 17 gaging stations for the period of 1941-1968. The future quality condition as used in this report is an estimate of the situation after the presently authorized developments, projects proposed for authorization, and private developments are placed in operation. The report estimates the present modified average concentration below Hoover Dam to be 760 mg/l and with future known developments, 1,010 mg/l. At Imperial Dam the comparable projections are 865 and 1,250 mg/l, respectively, under the same conditions. No time period is specified in the report to identify when the projected concentrations would be reached.

Computer Simulation of the Hydrologic-Salinity Flow System Within the Upper Colorado River Basin (USU)

Salinity conditions were investigated by Utah State University. In 1970, they issued a report entitled "Computer Simulation of the Hydrologic-Salinity Flow System Within the Upper Colorado River Basin." This study employed an electronic analog computer in developing a simulation model of the hydrologic and salinity flow systems of the Upper Colorado River Basin. Estimates were derived based on the 1931-1960 period and reflect cropping and riverflow regulation conditions as of 1960. The estimated salt load at Lees Ferry was 8.6 million tons per year of which approximately 4.3 million tons originated from natural sources, 1.5 million tons from within the agricultural system, and 2.8 million tons from other inputs to the system; thus, natural sources are thought to contribute 50 percent of the salt load, agricultural sources 17 percent, and unidentified sources 33 percent. The report states that the agricultural salt load and cropland consumptive use increase the total dissolved solids concentration within the Upper Basin by 104 and 113 mg/l, respectively. The model was designed to predict the effects of various possible water resource management alternatives.

Salinity of Surface Water in the Lower Colorado River-Salton Sea Area (USGS)

U.S. Geological Survey Professional Paper 486-E, entitled "Salinity of Surface Water in the Lower Colorado River-Salton Sea Area," was published in 1971. The report shows that during the period 1926-1962, the chemical regimen of the Colorado River at Grand Canyon and upstream, although probably somewhat different from the virgin regimen, was relatively stable. There may, however, have been small increases in average mineral concentrations, particularly toward the end of the period, caused by construction of reservoirs, increased irrigation, and out-of-basin diversions. The research also found that most of the mineral burden of the Colorado River, like most of its flow, originates in the Upper Basin. The largest individual increment to the mineral burden of the Colorado River below the compact point and above Imperial Dam was found to be the Blue Springs located near the mouth of the Little Colorado River. The report further shows that a principal increase in salinity in the lower reach is derived from irrigated land in the Parker and Palo Verde valleys. The increasing out-of-basin diversions are also reported as contributing to the rising salinity concentration levels.

The Mineral Quality Problem in the Colorado River Basin (EPA)

In 1971, the EPA released its report entitled "The Mineral Quality Problem in the Colorado River Basin." In this report, salinity and streamflow data for the 1942-1961 period of record were used as a basis for estimating average salinity concentrations under various conditions of water development and use. Under these conditions, concentrations at Hoover Dam were estimated to average about 700 and 760 mg/l in 1960 and 1970, and 880 and 990 mg/l in 1980 and 2010, respectively. At Imperial Dam, the report estimates 760 and 870 mg/l for 1960 and 1970, and 1,060 and 1,220 mg/l for 1980 and 2010 conditions. The findings of the study with respect to salinity sources were that natural sources accounted for 47 percent of the salinity concentrations at Hoover Dam. The remainder was accounted for by irrigation (37 percent), reservoir evaporation (12 percent), out-of-basin exports (3 percent), and M&I uses (1 percent).

The present annual economic detriments of salinity were estimated to total $16 million. The report further advises that if no salinity controls are implemented, it is estimated that average annual economic detriments would increase to $28 million in 1980 and $51 million in 2010. More than 80 percent of these detriments would be incurred by irrigated agriculture and the associated regional economy located in the Lower Basin and the southern California water service area.

The investigation examined three salinity control alternatives: (1) augmentation of basin water supply, (2) basin-wide salt load reduction program, and (3) limitation on further depletion of basin water supply. The study concluded that the salt load reduction program appeared to be the most feasible of the three alternatives. It then proceeded to develop a broad conceptual plan and related costs for such a program.

Lower Colorado Region Comprehensive Framework Study (WRC)

The report by the Water Resources Council dated June 1971 states that high levels of dissolved mineral salts in surface and ground waters are the major water quality problem in the region. With few exceptions, most surface and ground-water supplies have mineral concentrations exceeding 500 mg/l, and many exceed 1,000 mg/l. The salinity of the supplies affects domestic, industrial, and agricultural uses.

The Colorado River enters the region at concentrations exceeding 500 mg/l, varies between 500 and 900 mg/l at most diversion points, and increases to as high as 1,100 to 1,150 mg/l for short periods of time at Imperial Dam. Salinity increases in the Colorado River from Lees Ferry, Arizona, to Imperial Dam are due principally to inputs from saline springs and the concentrating effects of consumptive use and reservoir evaporation.

Dissolved solids concentrations in the Colorado River are estimated to increase about 55 to 75 percent between 1965 and 2020, with the exception of Imperial Dam where the concentration is estimated to double. These results are based on the assumptions that the Central Arizona Project is in operation and no salinity controls are incorporated in future developments.

Upper Colorado Region Comprehensive Framework Study (WRC)

This report by the Water Resources Council dated June 1971 states that salinity is the most serious water quality problem in the Colorado River Basin. Salt-loading and salt-concentrating effects of consumptive use or depletion are the primary causes of salinity increases. Salt loading principally results from salts contributed from diffuse and point sources of geologic origin and from salts carried in irrigation return flows.

Future dissolved solids concentrations were estimated for 1980, 2000, and 2020. The TDS concentration at Lees Ferry, Arizona, assuming no salinity improvement program, is projected at 820 mg/l for the year 2020, or 40 percent greater than the 1965 concentration. The major cause of the projected salinity increase is continued development of the region. It includes the additional stream depletions for irrigation, thermal power production and export, and the additional salt leached from newly irrigated lands.

State and Federal representatives in both the upper and lower Colorado regions agreed that the salinity improvement programs outlined in the Upper and Lower Colorado Framework Study documents would be part of a basin-wide approach to salinity management. The salinity improvement program consists of a salt-loading reduction

program which maintains concentrations at Lees Ferry at about 600 mg/l through the year 2020.

III PROGRAM OBJECTIVE

Building on the prior investigations of the salinity conditions in the Basin, The Bureau of Reclamation initiated a Water Quality Improvement Program in early 1971. The objective of the program is to maintain salinity concentrations at or below levels presently found in the lower main stem of the Colorado River. In implementing this objective, the salinity problem will be treated as a basin-wide problem, recognizing that salinity levels may rise until control measures are made effective while the upper basin continues to develop its compact-apportioned waters.

In moving toward this objective, corollary activities will, to the extent found feasible, encompass:

1. Stimulating improvements in management of water supplies in water systems,
2. Coordinating and integrating implementation of salinity control measures with basin-wide water resource management plans,
3. Recommending institutional and legal arrangements essential for efficient and equitable accomplishment of salinity control,

4. Removing salinity or otherwise controlling the concentration levels economically, safely, and without adverse side effects to the ecology and the environment,

5. Providing the requisite means for public participation in the choice of and commitment to water quality improvement measures, and

6. Initiating the needed installation of structural and nonstructural measures for salinity control to achieve substantial salt load reductions in this decade and early in the subsequent decade.

IV PROGRAM STRUCTURE

The program is structured within the framework of existing Departmental responsibilities and legislative requirements. These provide the basis for a basin-wide planning approach to salinity control. The program places early emphasis upon salinity control procedures whose implementation does not involve structural measures. Thus the least costly measures will be undertaken first. Concurrent feasibility investigations are scheduled on various irrigation, point, and diffuse sources. Related basin-wide studies are scheduled to over-view individual control projects, assess implications of new technology, and provide guidance to the selection of implementation measures. The program will be closely integrated with ongoing activities involving development of the Western U.S. Water Plan, weather modification, desalting, geothermal resources and research. The activities will be closely coordinated with other Federal, State, and local agencies, and public and private groups interested in the program. Cost-sharing and repayment formulas would be developed and recommended prior to implementation of the structural measures. Special organizational arrangements are being made within the Bureau of Reclamation to enable close liaison with affected entities and to enable efficient prosecution of the work.

Departmental Responsibilities

The Secretary has broad as well as specific responsibilities under applicable laws to manage the water resources of the Colorado River Basin to (1) apportion the waterflows according to the Colorado River Compact of 1922, (2) meet commitments to Mexico under the International Water Treaty of 1944 with that nation, (3) conform to the requirements of the Supreme Court Decree of 1964, (4) meet specific contractual obligations with water users in the United States, (5) develop and manage water resources in accordance with specific authorizing legislation and in the public interest, (6) protect the recreation, fish and wildlife, and environmental values, and (7) assist in implementing the provisions of the Water Quality Act of 1965 and amendments relating thereto.

There are many documents that river operations must conform to, including the Colorado River Basin Project Act, September 30, 1968. Criteria for Coordinated Long-Range Operation of Colorado River Reservoirs, June 10, 1970, were developed in accordance with this act.

Within the context of these responsibilities and legal requirements certain considerations are paramount: (1) There can be wide fluctuations in the concentration of dissolved solids above Lake Powell as a result of annual variations in precipitation and the management of the available water resources, (2) the total available water resources of the river are allocated by interbasin and interstate compacts and the international treaty, (3) the treaties and decrees have apportioned water quantity but are silent on water quality, and (4) studies made by this Department, the Environmental Protection Agency, the Colorado River Board of California, and the Water Resources Council project increases in salinity unless control measures are taken concurrent with development for use of presently allocated water.

In recognition of the effects of the proposed developments on the salinity of the river, the Congress specifically directed the Secretary of the Interior to make water quality studies and to devise plans for improvement. This is provided for in three public laws:

1. Section 15 of the authorizing legislation for the Colorado River Storage and Participating Projects states: "The Secretary of the Interior is directed to continue studies and make reports to the Congress and to the States of the Colorado River Basin on the quality of water of the Colorado River."

2. Section 15 of the authorizing legislation of the Navajo Indian Irrigation Project and San Juan-Chama Project states: "The Secretary of the Interior is directed to continue his

studies of the quality of the water of the Colorado River system, to appraise its suitability for municipal, domestic, and industrial use, and for irrigation in various areas of the United States in which it is proposed to be used, to estimate the effect of additional developments involving its storage and use (whether heretofore authorized or contemplated for authorization) on the remaining water available for use in the United States, to study all possible means of improving the quality of such water, and of alleviating the ill effects of water of poor quality, and to report the results of his studies and estimates to the 87th Congress and every 2 years thereafter."

3. Authorizing legislation for the Fryingpan-Arkansas Project, Colorado, contains similar language pertaining to water quality reports and stipulated that the first report should be provided by January 3, 1963, to be followed by submission of reports every 2 years thereafter.

These acts provide authority to this Department for basin-wide planning of a salinity control program. Feasible salinity control projects involving construction will require congressional authorizations. The responsibility to plan and implement the control programs has been entrusted to the Bureau of Reclamation, with the function to be coordinated with other agencies of this Department such as the Office of Saline Water, the Office of Water Resources Research, the Geological Survey, Bureau of Land Management, the Bureau of Indian Affairs, Bureau of Sport Fisheries and Wildlife, Bureau of Outdoor Recreation, and the Bureau of Mines. As planning and implementation progress, it is expected that particular contributions can be made by each of these agencies to the successful conduct of the comprehensive program for salinity control.

Organization

The immediate responsibility for direction of the Colorado River Water Quality Improvement Program has been assigned to the Assistant Commissioner - Resource Planning with strong coordinative ties with the Assistant Commissioner - Resource Management. The field planning, construction, and operation activities will be handled by the Regional Directors, Regions 3 and 4, with assistance as needed being provided by the Engineering and Research Center. A new division to be entitled "Division of Colorado River Water Quality" will be established within the Engineering and Research Center in Denver to serve as the focal point for the program. The Division Chief will report directly to the Assistant Commissioner - Resource Planning. Leadership responsibilities of this Division will cover such activities as coordinating, developing, and expediting the program; closely working with and integrating elements of the program with other governmental entities; and developing coordinative ties with Federal, State, and local agencies and public and private groups having a mutual concern and interest in the salinity control program. Program progress will be monitored, policy positions analyzed, and recommendations developed for consideration by the appropriate decisionmaking levels within the Department of the Interior. The Division will maintain close liaison with the Westwide management team to insure compatibility and integration of its program with the Western U.S. Water Plan. Work involving the allied programs will continue to be planned and implemented according to current procedures that will be closely observed to insure timely application of results to the salinity control program.

Program Elements

The program is structured to investigate the feasibility of constructing point, diffuse and irrigation source control projects; initiating immediate nonstructural control measures in the field of irrigation scheduling and management; and conducting essential supporting studies of basin-wide applicability. The latter involve institutional and legal matters, mathematical modeling of the river system to measure impacts and guide choices, economic analysis of water quality costs and benefits, and prospects of adopting alternative conceptual bases for the program such as controlling salinity on a large scale at diversions to points of use rather than control of sources (or combinations thereof).

Figure 2 identifies the specific elements of the program and indicates the period during which the work is proposed to be accomplished and Figure 3 shows the location of the various projects.

Program Costs

Currently the program is funded at a level of $455,000, with a proposed expansion of the program to $1,005,000 in fiscal year 1973. The planning activities as scheduled in fiscal years 1972 through 1981 total approximately $18 million. Construction activities which may be required within this time frame could involve costs in the order of magnitude of $400 to $500 million. Such funding would be determined by congressional authorization and appropriate non-Federal cost sharing and repayment. The most promising prospects for achieving salinity control have been screened and, therefore, effort will be concentrated on feasibility investigations to expedite movement of salinity control projects through the congressional authorization processes.

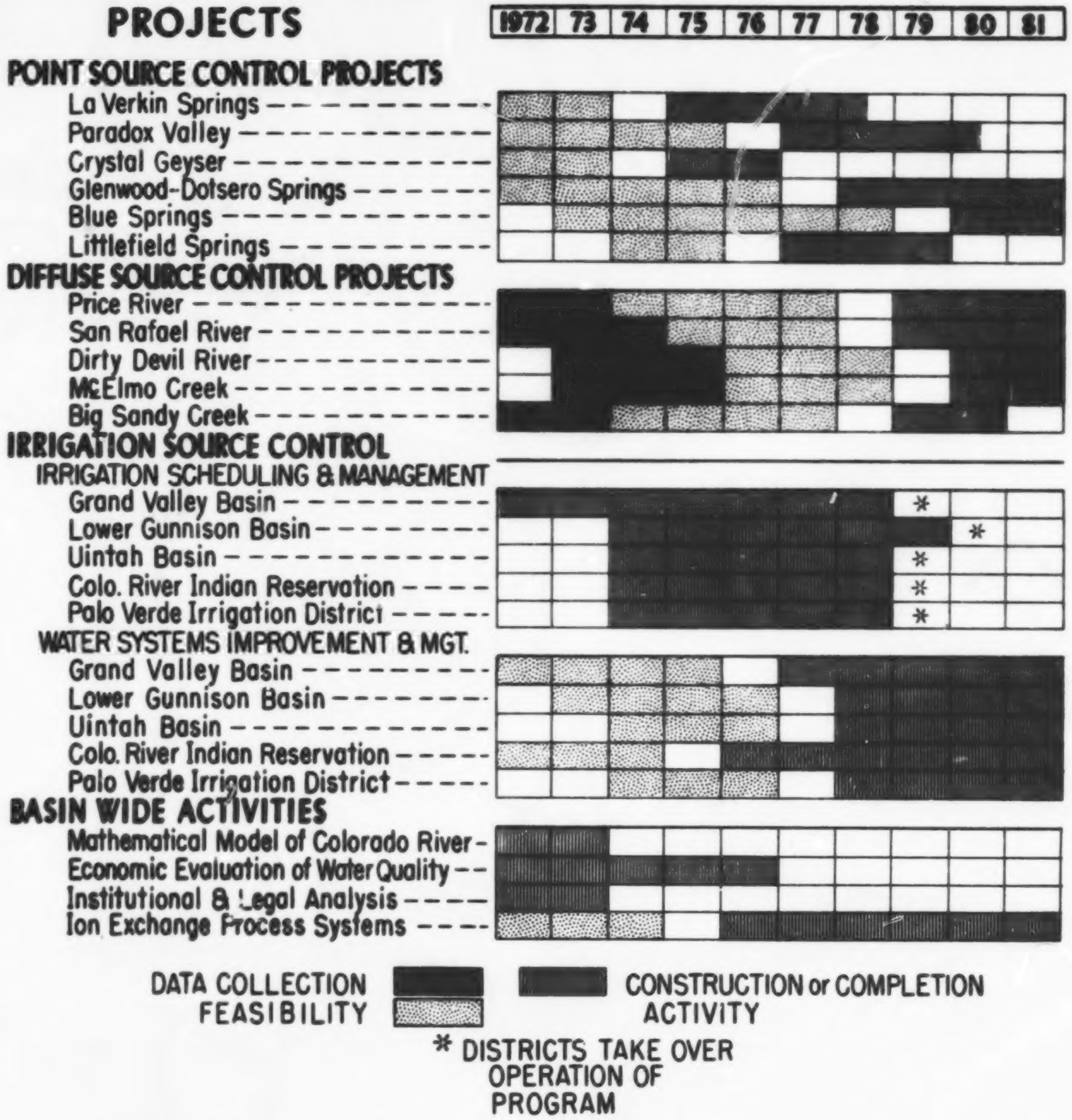
Program Financing and Repayment

The investigation program would be financed by the Federal Government under the authority of laws previously cited herein. As feasibility of specific control projects is demonstrated, beneficiaries

Figure 2

COLORADO RIVER

WATER QUALITY IMPROVEMENT PROGRAM



]

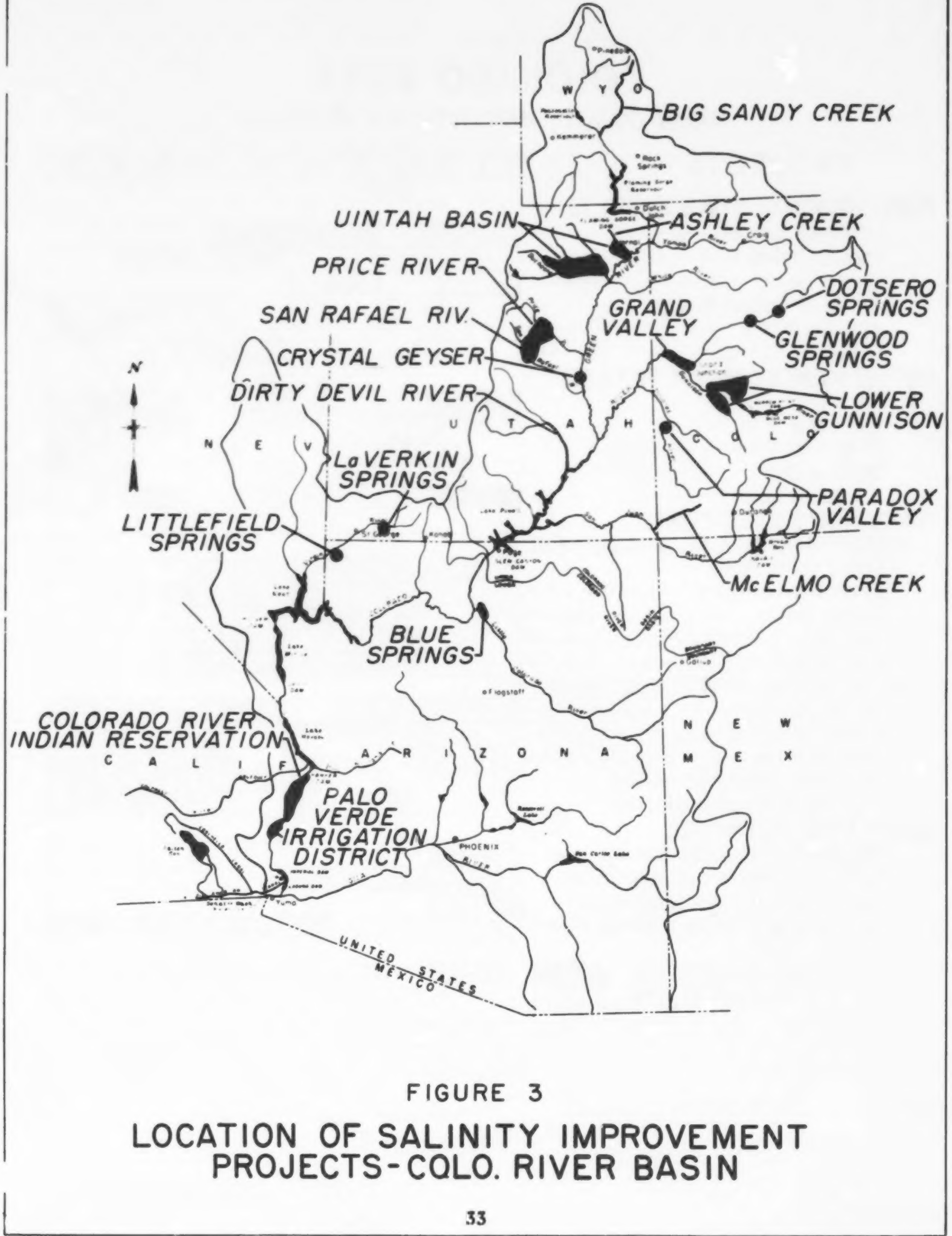

W Y O
Pinedale
Kemmerer
Rock Springs
BIG SANDY CREEK
UINTAH BASIN
ASHLEY CREEK
PRICE RIVER
GREEN
DOTSERO SPRINGS
SAN RAFAEL RIV.
GRAND VALLEY
GLENWOOD SPRINGS
CRYSTAL GEYSER
LOWER GUNNISON
DIRTY DEVIL RIVER
U T A H
C O L O
N
N E V
LaVERKIN SPRINGS
PARADOX VALLEY
LITTLEFIELD SPRINGS
St George
McELMO CREEK
BLUE SPRINGS
Flagstaff
Gallup
COLORADO RIVER INDIAN RESERVATION
C A L I F
A R I Z O N A
N E W M E X
PALO VERDE IRRIGATION DISTRICT
PHOENIX
Yuma
UNITED STATES
MEXICO

FIGURE 3

LOCATION OF SALINITY IMPROVEMENT PROJECTS-COLO. RIVER BASIN will be identified and cost-sharing and repayment formulas will be developed. Through such cost sharing, it is anticipated that direct non-Federal financial support would be forthcoming to implement the construction phase of the program. This may require new institutional arrangements not only as related to repayment but also to operation and maintenance of constructed facilities.

As indicated under the corollary principles guiding the program, every effort would be made to move the feasible projects into the construction phase within a period of 1 to 2 years following a favorable finding of feasibility.

Related Program Features

Provision is built into the program to undertake other supporting and feasibility investigations. As now developed, the program draws heavily on precedent studies. The more detailed investigations to be done under this program may reveal that some of the projects should not be implemented because of economic, physical, or environmental considerations. Accordingly, concurrent analysis of other alternatives will need to be conducted. The kind of work contemplated here would involve a careful analysis of the salinity sources in the Lower Basin. Previous studies have failed to adequately investigate the lower reach from Parker to Imperial Dam. Such work will, therefore, be fitted into the program and would be accompanied with other items such as prospects for desalting return flows from the Palo Verde Irrigation District and a general study of brine disposal possibilities in the lower reach of the river. Should findings of the supporting studies involving the use of the ion exchange processes prove attractive, then an analysis would be needed to identify the best ways to use the process in the overall program.

The program will be faced with uncertainties with respect to potential advances in technology not only in the field of desalting but also in other areas such as development of antitranspirants, evaporation suppression, enhancement of salt precipitation reactions in large reservoirs, and development of lower cost energy sources (breeder reactors and fusion).

In consideration of the foregoing, decision points will be utilized in the program to determine direction as the feasibility and related studies are completed. Salinity control on the scale contemplated represents a pioneering effort in which alternative solutions will need to be assessed for effectiveness, environmental consequences, economic impact, and equitability of the measures to the States involved. An appraisal of program direction and a description of program accomplishments will be made to Congress at 2-year intervals as part of the biennial report on continuing studies of the quality of water of the Colorado River Basin. The directive for preparing the biennial report is contained in three separate public laws which authorized the (1) Colorado River Storage Project and participating projects, (2) Navajo Indian Irrigation Project and San Juan-Chama Project, and (3) Fryingpan-Arkansas Project.

Allied Programs

Allied programs of the Bureau of Reclamation and other agencies will be coordinated with this salinity control effort. The allied programs, particularly those involving augmentation of water supply, can be expected to have important impacts on the concentration of dissolved constituents in the river system. Accordingly, as these plans emerge, their impacts will be assessed and measured for effectiveness along with the specific control projects identified in the water quality improvement program. A discussion of the allied program is provided in a subsequent section of this report.

V EFFECT OF PROGRAM

The amount of salt load reduction that can be achieved through control of point sources, diffuse sources, and irrigation sources cannot, at this time, be estimated with a high degree of accuracy. Good data exist on the annual salt tonnage output from the point and diffuse sources but detailed engineering plans are needed to determine the amount of salt load reduction possible, the cost, and the feasibility of the plan. Also, the ongoing research by Colorado State University now being financed by EPA, and the research underway by the Bureau of Reclamation will need to be completed to derive reliable estimates of salt load reduction and concentrating effects generated by the irrigation scheduling and water systems improvement programs.

Recognizing the foregoing limitation, the Water Quality Improvement Program as now scheduled is estimated to achieve a reduction of about 140 mg/l at Hoover Dam and 160 mg/l at Imperial Dam including Blue Springs. This assumes that all point and diffuse source projects, irrigation scheduling and management activities, and the water system improvement and management projects now included in the program are implemented.

The total capital costs for the point and diffuse source control projects are in the order of magnitude of $150 to $200 million excluding Blue Springs. Insufficient data preclude making an order of magnitude estimate for this point source. The irrigation scheduling and management costs would total $4 to $5 million within the program period. Subsequently, this program would be continued by the water users. Order of magnitude costs for improvement of the water systems have been made and these range from $240 to $300 million. Summation of the capital costs for the point and diffuse source control projects exclusive of Blue Springs, the water systems improvement projects, and the irrigation scheduling and management activities indicates an order of magnitude of $400 to $500 million.

Relating the program accomplishments to time periods, it is estimated that the program if implemented according to the proposed schedule could achieve a reduction of 60 and 160 mg/l at Imperial Dam by 1980 and 1990, respectively. The control measures included for the 1980 reduction include LaVerkin and Littlefield Springs under the point source control program and the irrigation source control programs in the Grand Valley and Lower Gunnison Basins plus the Colorado River Indian Reservation and the Palo Verde Irrigation District. The reduction by 1990 would be achieved through control of the remaining point, diffuse, and irrigation sources.

To provide requisite initial guidance to the selection of projects to be studied at the feasibility level, a ranking based on cost effectiveness has been prepared. This along with other factors such as quantities of potential salt load reduction, reliability of currently available data regarding the projects, knowledge of the kind and capacity of physical works required, prospects for achieving early effects through salt load reductions and potential economic viability of the projects were considered. The cost effectiveness is based on dollars per ton per year amortized over a 50-year period. The data are shown in Table 4, Potential Effects and Costs - Point and Diffuse Source Control Projects, and Table 5, Potential Effects and Costs - Irrigation Scheduling and Management and Water Systems Improvement Projects.

The irrigation scheduling and water systems improvement programs are to be closely integrated. Both programs contemplate heavy participation of the water users. The irrigation system improvement program would provide direct benefits to the water user organizations. This would include such factors as labor savings, more efficient water deliveries, reduced operational costs, and providing a basis for more efficient layouts of irrigated fields. Accordingly, in compiling the cost effectiveness, it was assumed that one-half of the capital costs of the water systems would be paid for by the water users as a benefit to the irrigation system of the project. The remainder of the cost is assumed to be allocated to salinity control and would be subject to cost sharing.

Table 4

Potential Effects and Costs - Point and Diffuse Source Control Projects

Projects	Present salt loading (1,000's ton/yr)	Estimated reduction (1,000's ton/yr)	Effect at Hoover Dam (mg/l)	Effect at Imperial Dam (mg/l)	Construction cost ($1,000,000's)	Construction period (FY)	Cost effectiveness (dollars/ton/yr)
LaVerkin Springs	100	80	-6	-8	8-10	1975-78	2.00-2.50
San Rafael River	190	90	-7	-8	10-15	1979-81	2.20-3.30
Paradox Valley	200	180	-14	-15	25-35	1977-80	2.80-3.90
Price River	240	100	-8	-9	15-20	1979-81	3.00-4.00
Dirty Devil River	200	80	-7	-8	15-20	1980-82	3.80-5.00
Littlefield Springs	30	30	-2	-2	6-8	1977-79	4.00-5.30
Glenwood-Dotsero Springs	500	200	-15	-17	40-60	1978-81	4.00-6.00
Big Sandy River	180	80	-7	-8	20-25	1979-80	5.00-6.30
Mc lmo Creek	115	40	-3	-4	10-15	1980-82	5.00-7.50
Crystal Geyser	4	4	1	1	1-2	1975-76	5.00-10.00
Blue Springs*	550	250	-16	-19	-	-	-
Total**	2310	1130	-90	-100	150-200	-	-

* Insufficient data to estimate cost
** Total values are rounded

Table 5

Potential Effects and Costs
Irrigation Scheduling and Management and Water Systems Improvement Projects

Areas	Present Salt Loading (1000's tons/yr)	Estimated Reduction (1000's tons/yr)	Effect at Hoover Dam (mg/1)	Effect at Imperial Dam (mg/1)	Irrigation Scheduling Costs ($1,000,000)	Water Systems Improvements Total Cost ($1,000,000)	Water Systems Improvements Assumed Federal Cost ($1,000,000)	Cost Effectiveness (dollars/ton/yr)
Lower Gunnison Basin	1,100	300	-23	-26	1-1.5	80-100	40-50	2.70 - 3.30
Uintah Basin	450	150	-12	-14	1-1.5	40-50	20-25	2.70 - 3.30
Grand Valley Basin	700	200	-15	-17	0.8-1.0	70-80	35-40	3.50 - 4.00
Palo Verde Irrigation District	90	23	0	-5	0.4-0.5	30-40	15-20	13.00 - 17.00
Colorado River Indian Reservation	30	7	0	-2	0.3-0.5	20-30	10-15	28.00 - 43.00
Totals*	2,370	680	-50	-60	4-5	240-300	120-150	---

*Values shown are rounded

At this time, the separation of effects between irrigation scheduling and water system improvements cannot be made. The effects will vary between areas depending upon soil, geologic, drainage, and topographic conditions, as well as the condition of present irrigation systems and the irrigation efficiencies now being attained by the water users. It is reasonable, however, to assume that irrigation scheduling and management will have a significant effect and for this reason early implementation would be a desirable feature of the program.

The total reduction of 160 mg/l at Imperial Dam as now estimated cannot maintain the salinity levels at or below present levels. Other measures involving combinations of desalting, weather modification, vegetation management, and channelization are required.

Vegetation management and channelization measures could be installed in accordance with the Colorado River Basin Project Act. Through these measures, there could be a water recovery of perhaps 200,000 acre-feet during the period 1980 to 1990 in the vicinity of Imperial Dam. This would achieve a substantial reduction in concentration at Imperial Dam at a cost less than some of the other control measures. Difficulties of implementing such a program are recognized. The program would need to protect the fauna and achieve environmental enhancement. Research into these areas is needed.

Increased confidence in weather modification leads to the assumption that 1 million acre-feet of additional flow could be expected by 1980 and possibly 2 million acre-feet by 1990. The additional water would be a significant advantage of this method.

Desalting will also be an important function in maintaining salinity at the present level. A specific desalting process can be designed to maintain the flow and quality desired at a given location permitting wide flexibility. It is estimated that desalting 500,000 acre-feet from a concentration of 1,000 to 735 mg/l would result in a 20 mg/l reduction in the concentration at Imperial Dam by 1980. Increased desalting by 1990 and the year 2000 could bring about reductions of 75 and 125 mg/l, respectively.

The interactions of the various control measures are physically related to one another and hence the order and time of accomplishment are important in assessing the overall effect.

The average annual salinity concentration of the Colorado River at Imperial Dam during the period 1941 to 1968 (most recently published data) was 751 mg/l. The annual salinity concentrations during this same period have ranged from a minimum of 649 mg/l in 1949 to a maximum of 918 mg/l in 1956. The monthly salinity concentrations of the Colorado River at Imperial Dam during the period

1941 to 1968 have experienced an even wider range from a minimum of 551 mg/l in December 1952 to a maximum of 1,000 mg/l in January 1957.

Levels of salinity concentrations presently found in the lower Colorado River vary depending on the time period used to describe the level. As indicated above, the average for a year is greater than the level during the period 1941 to 1968 and the peak monthly concentration is even greater than the level for a year.

In order to depict the effects of the Water Quality Improvement and Allied Programs, Table 6 was developed showing the projected reductions in salinity concentrations for each program and the estimated effects on the synthesized salinity levels at Imperial Dam.

Table 6

PROJECTED PROGRAM REDUCTIONS - COLORADO RIVER AT IMPERIAL DAM

(Average annual values in mg/l - 1941-68 period of record)

	1970	1980	1990	2000
Estimated salinity level (Full development - no control program)	865	1,000	1,200	1,250
Range	(750-1,060)	(860-1,220)	(1,040-1,470)	(1,080-1,530)
Projected program reductions				
Point, diffuse, and irrigation source control	(-)	(-60)	(-160)	(-160)
Vegetation management and channelization	(-)	(-)	(-50)	(-50)
Desalting	(-)	(-20)	(-75)	(-125)
Weather modification	(-)	(-40)	(-70)	(-70)
Total program reduction	-	-120	-355	-405
Estimated salinity level (Full development with control programs)	865	880	845	845
Range	(750-1,060)	(740-1,100)	(685-1,115)	(675-1,125)

The values in the table are initial estimates based on the average hydrologic conditions for the period of record 1941-1968.

The 1970 average annual value of 865 mg/l has been derived on the assumption that present developments in the basin were completed and operating during the period of record. In other words, the effects of water quality of all present developments have been extended back to 1941 from the time they became operational.

Similarly, the average annual values for the years 1980, 1990, and 2000 were synthesized to reflect the influence on water quality during the period of record of water resource developments expected to be completed by those dates. These estimates must be regarded as initial approximations. The feasibility and related studies, buttressed by additional research, will improve reliability of the estimates.

It should be recognized that the values in the table are computed average annual values at Imperial Dam under the stated assumptions. The average annual modified value for 1970 of 865 mg/l based on the 1941 to 1968 period would probably have ranged from an annual minimum of 750 mg/l to an annual maximum of 1,060 mg/l. However, with Lakes Powell and Mead regulating the Colorado River, it would require several consecutive low-flow years to produce an annual salinity concentration of 1,000 mg/l, or higher, at Imperial Dam.

Historically, records at Imperial Dam show that the average salinity concentration for January 1957 was 1,000 mg/l and for December 1967 it was 992 mg/l. Six other months in the period 1941-1968 have had average concentrations above 960 mg/l. However, with present development, it is probable that the average monthly concentrations for these 8 months would have exceeded, 1,000 mg/l. Furthermore, with present developments, the 1,000 mg/l mean monthly concentration at Imperial Dam would have been exceeded in 40 months during the period 1941-1968.

It is not possible to predict future salinity concentrations for any particular month, nor can it be assumed that past flow and concentration cycles will be repeated in the future.

In view of the foregoing, it is essential that feasibility studies be pursued on point, diffuse, and irrigation sources to disclose the maximum improvement in water quality that can be achieved. These must be coordinated with allied programs and fitted into a basin-wide water resources management plan. The studies must develop the full costs involved, identify the control means, assess benefits, identify beneficiaries, present financial plans, display the tradeoffs, and specify the time required to achieve specific degrees of water quality improvement for particular reaches of the river. The comprehensive plan for water quality improvement must be engineeringly feasible, politically acceptable, and administratively viable through appropriate institutions. This then would permit the salinity levels to be maintained at an average annual level of about 845 mg/l while the Upper Basin States continued to develop up to their apportionment under terms of the Colorado River Compact.

It is premature to define numerical standards of salinity levels at Imperial Dam now or in the next 2 or 3 years. It is essential that the available technical knowledge of the physical and social factors involved and their interrelationships and the probable consequences of proposed changes be fully understood before applying numerical standards.

VI DESCRIPTION OF WATER QUALITY IMPROVEMENT PROGRAM

The prior studies of water quality in the Colorado River by the Bureau of Reclamation, the EPA, and the Colorado River Board of California have served to define the problems and outline potential control measures. They are not, however, sufficient to undertake immediate construction of control measures. Cost effectiveness analyses have been prepared on the basis of reconnaissance studies.

For example, point sources of salinity have been geographically identified, salinity concentrations have been measured, and output of salt load estimated. Neither the feasibility of capturing these flows has been verified by requisite field geological explorations nor the consequence of such proposed actions assessed. Similarly, diffuse sources of salinity have been located but reliable measurement of salt loading cannot be made because adequate records are not available. Moreover, practical methods for controlling the salt loading from such sources still need to be developed.

With respect to irrigated lands, it is anticipated that improvement in management and use of water on the irrigated farms will result in reduced salt loading thereby improving the quality of the receiving stream. Such action, buttressed by improvements in water conveyance systems, involving seepage reduction through canal lining and improvement in operational techniques, also is expected to contribute toward reduced salt loadings in the river. Complex interrelationships of human activities and physical field conditions must be analyzed to determine the amount of salt load reduction that could be achieved.

This chapter describes the details of the various elements of the program. Details of some of the projects are lacking due to the scarcity of knowledge and basic data for making judgments prior to undertaking the studies. The studies and activities are described in the approximate order in which they are expected to yield the greatest returns for the least investment of funds. These activities are described in the following sequence: the mathematical model for the Colorado River, other basin-wide activities which will have a bearing to some degree on all the investigations, irrigation source control, point source control, and diffuse source control.

Basin-wide Activities

These activities will include the development of a mathematical simulation model of the Colorado River system, further development of economic evaluation methods for water quality as an adjunct to the model, an in-depth study of the legal and institutional aspects involved, and the potential application of salinity reduction processes which have not been previously investigated.

Mathematical Model for Colorado River

To aid in evaluating the Water Quality Improvement Program, a mathematical simulation model for the Colorado River System is being developed. The model employs various aspects of systems analysis, probability theory, mathematical statistics, and operational research. In addition, computer science, engineering mathematics, and numerical analyses are utilized. The model would simulate the river system for both water quantity and water quality. Quality will be displayed in terms of the total dissolved constituents and the major anions and cations. Models already in existence will be used to the maximum extent possible.

In concept, the model incorporates the use of deterministic and/or probabilistic inputs and demands to measure system response or yield under specific operational criteria. The model consists of five fundamental computational blocks which are primarily submodels of the overall system. Each primary submodel can be used independently for a particular system objective. Initially the model will be developed with the first two submodels. Subsequently, the remaining three submodels will be incorporated.

The five computational blocks or submodels are as follows:

1. Data analysis submodel. This block is utilized to analyze and evaluate the basic time series data. The block is used to

develop builder functions to relate quantity and quality and transfer information from one point to another in the system. Statistical information and equations are developed to allow the synthetic generation of a longer time series from a shorter series while preserving the statistical characteristics of the shorter series.

2. Simulation submodel. Provides an operational simulation of the basin based on a series of nodes with five system objectives utilized in each node, handles surface and ground-water flows, and specifies the operating constraints or conditions of flow, storage, and quality that must be met.

3. Sensitivity and impact analysis submodel. Identifies effects of factors such as changes in frequency distribution curves and ranks the impacts of operational influences; e.g., how do irrigation demands effect power production.

4. Linear optimization submodel. Identifies the optimal economic operating conditions required to achieve specified system objectives.

5. Dynamic system submodel. With operational rules specified, this submodel provides a dynamic optimization of the system for specified objectives such as water quantity and quality at each node point moving either up or downstream.

The model will make it possible to evaluate the quality changes under various flow regimes so time changes of quality can be presented on a probability basis. The effects of salinity control projects, weather modification, vegetation management and channelization, desalting and augmentation by import, and water resource development could be analyzed through use of the model. The model will be of great value in developing alternative plans of water use and regulation. It could be used to optimize plans, define changes in present operating criteria for salinity control, and evaluate impacts of salinity control projects and new water resource developments on the salinity of the system.

Economics of Water Quality Management

Proposals for salinity management actions will be evaluated to identify potential benefits and costs. Because the proposed salinity control measures are expected to be costly, sensitivity analysis will be made on various components. Alternative remedial actions will be analyzed along with associated impacts, both beneficial and adverse. Beneficial effects from reductions in salinity concentration in the river include the avoidance of decreased crop yields, maintenance of higher quality municipal and industrial water, and savings in water treatment costs. The estimation of secondary and indirect effects on the economy resulting under conditions with and without alternative salinity control measures will also be considered.

Equally important but not as easily quantified are the intangible detriments, such as possible environmental effects and the international relationship with Mexico.

The economic appraisal will utilize the simulation model of the entire Colorado River Basin. The structure and inputs for optimization submodels will be developed. The comprehensive work done by the EPA will be reviewed to determine modifications and additions of the most value to program needs. This definition-type study is currently underway. It will bring together all the past research efforts and outline a plan of action for subsequent years. New economic evaluation procedures will be explored. Data gaps will be filled and optimization submodels formulated to test the economics of alternative salinity management projects. This would be followed by economic evaluations of individual projects and the overall proposed system of salinity control.

Institutional and Legal Analysis

Operations of the Colorado River are controlled to a large degree by compacts, Federal laws, State laws, power and water contracts, an international treaty, and a U.S. Supreme Court decree. These legal and institutional arrangements place constraints on a water quality improvement program. It is therefore important that every potential corrective action includes consideration of institutional and legal aspects along with engineering and economic feasibility. New legislation or special interbasin agreements may be necessary before certain programs can be accomplished. This analysis will document and identify the operational constraints and establish the legal framework that may be required to pursue implementation of salinity control measures.

Some of the controlling documents are:

Colorado River Compact - November 24, 1922
Boulder Canyon Project Act - December 21, 1928
California Limitation Act - March 4, 1929
Seven-Party Water Agreement - August 18, 1931
Boulder Canyon Project Water Contracts - February 21, 1930, through the present
Boulder Canyon Project Power Contracts - April 26, 1930, through the present
Boulder Canyon Project Adjustment Act - July 19, 1940
Mexican Water Treaty, 1944
Upper Colorado River Basin Compact - October 11, 1948
Colorado River Storage Project Act - April 11, 1956
Supreme Court Decree in Arizona v. California - March 9, 1964
Lake Mead Flood Control Regulations - July 29, 1968

Colorado River Basin Project Act (Public Law 90-537, 90th Congress, approved September 30, 1968)

Criteria for Coordinated Long-Range Operation of Colorado River Reservoirs - June 10, 1970

State Water Laws

Winters Doctrine

Eagle County Case

Contracts for Sale of Water from Boulder Canyon Project and Colorado River Storage Project Reservoirs

Other Contracts Related to Thermal Powerplants

Water Quality Act of 1965 and Amendments

Environmental Protection Act

Executive Orders of the President

Ion Exchange Desalting

The Office of Saline Water is conducting a parametric study of the preliminary feasibility and cost of utilizing large-scale ion exchange systems to control salinity levels on the Colorado River at various points such as Parker or Davis Dam. This study would determine the plant boundary costs of reducing the salinity in 100 mg/l increments down to a lower limit of 500 mg/l.

The study is considering the various costs of regeneration, possible costs of resins if billion gallons per day plants were built, and various salinities of feed water from 750 up to 1,000 mg/l. Feed-water flows to be considered in the study will range from 500 to 5,000 cfs.

A small ion-exchange pilot plant is being installed at a selected site on the Colorado River to verify the theoretical results of the parametric study. Housing for the pilot plant and power for operation would be furnished by the Bureau of Reclamation. Verification runs are expected to take 90 days.

Ion exchange was selected for special study because it may hold better prospects for most economically reducing the salinity of water having concentrations of 700 to 1,300 mg/l by 200 to 500 mg/l than other desalting processes. This study will provide an opportunity to analyze alternative concepts of salinity control not heretofore critically studied. Involved would be control of the salinity at levels required for a particular use, with the water being treated within the delivery system to the use areas. Should the initial studies show favorable economical relationships, feasibility studies of large-scale installations could be made and integrated into a system analysis of the river using the ion-exchange process at or in key water-delivery systems.

Irrigation Source Control

The principal irrigated areas contributing to the salinity of the Colorado River system are the Grand Valley and Lower Gunnison Basins in Colorado; the Uintah Basin in Utah; and the Colorado River Indian Reservation in Arizona and the Palo Verde Irrigation District lands in California. To alleviate this source of salt loading and the concentrating effect caused by the consumptive use of water, on-farm irrigation scheduling and water management will be undertaken. This program will be coordinated with water systems improvement and management programs within each of the areas. Completed research indicates that improved on-farm irrigation scheduling and water management is likely to be among the least expensive methods of reducing salinity levels.

Irrigation Scheduling and Farm Management

Objectives. The principal objective of this program as related to the Colorado River Water Quality Improvement Program is to reduce the salt loading of the Colorado River contributed by irrigation return flows. By minimizing irrigation water's contribution to the ground-water regime that is in contact with saline geological formations, a substantial reduction in the total volume of salt being yielded to Colorado River is expected. Some water would be salvaged through a reduction of nonbeneficial consumptive use in seeped and shallow water table areas. The salvaged water and the reduced diversions would be available for further uses such as increasing water available for other withdrawals, increasing streamflows in some river reaches, or increasing reservoir storage for multipurpose uses.

The principal objectives of this program as related to the irrigators include an increased net return through greater yields and improved crop quality with lower production costs. Irrigation scheduling and a farm management program will help assure the efficacy of irrigation for agricultural production and reduce its overall environmental impact on the water and land resource. A desirable feature of this program is that the benefits will be sufficient to support an initial level of irrigation improvement.

Three levels of obtainable irrigation efficiencies can be realized on an operating irrigation project. The first is realized by the irrigator when making proper and timely irrigation applications without an increased labor input. The second level of improved irrigation efficiency will be realized through additional labor involvement in the on-farm operation.

The third increment of irrigation efficiency is associated with improved on-farm irrigation systems and improvement of the total distribution system. This final level can only be realized with a substantial investment. Improvement of the on-farm irrigation systems could be accomplished through private investment with some assistance from the U.S. Department of Agriculture, Rural Environmental Assistance Program.

The primary technique employed by this program is the development and dissemination of information on timing of irrigations and their applied amounts with a computer program. By developing an accurate and timely water budget and giving operational considerations to the root zone reservoir, the basis for high irrigation efficiencies can be maintained and the first increment of improved irrigation efficiency realized. Through employment of other good management tools, proper operational techniques along with the right irrigation system, these improved irrigation efficiencies can be further optimized within the physical constraints of an irrigated area. Through interaction with irrigators and improved education and communication with the involved organizations, these criteria can be developed and implemented.

Program Evaluation. The very essence of the effectiveness of this program is motivation at all levels, but most important at the farmer/irrigator level of involvement. With a program of this nature, motivation can best be developed by evaluating the program and identifying its benefits and the beneficiaries. By showing a farmer real benefits associated with this program, he will be stimulated to respond to a suggested irrigation schedule and become motivated to make an effort to improve his irrigation operation. His level of response will directly affect his level of returns. When these benefits are large enough, the farmer or another direct beneficiary will be expected to finance a portion of this program's operation and provide the capital investment needed. Measurements of the present and future conditions with regard to such items as crop yields, crop quality, water use, fertilizer use, production costs, and ground-water levels will need to be documented. This documentation of the effects of this program on the initial areas will thus allow easier implementation on subsequent areas.

Proposed Areas. It is believed that the earliest and most dynamic results on quality will be obtained through irrigation scheduling in the Upper Basin. This program will, therefore, be initiated immediately in the Grand Valley area of the Upper Basin. In fiscal year 1974, this program is scheduled to be expanded into other areas in the Upper Basin and introduced into two areas in the Lower Colorado River Basin. The initial areas to be considered for irrigation scheduling under this program are:

1. Grand Valley Area (Presently there are 76,000 acres being served by private districts and the Grand Valley Project in this area.)

2. Lower Gunnison Basin (Present irrigated acreage is 160,000 acres). Projects under construction will add 17,000 acres to this area.

3. Uintah Basin (170,000 acres are located in this area).

4. Colorado River Indian Reservation (The present irrigated area here is 55,600 and projected to increase to 99,400.)

5. Palo Verde Irrigation District (There are 91,500 acres of land irrigated in this area.)

Water Systems Improvements and Management

An important adjunct to on-farm management of water involves improvement of the water conveyance systems to reduce losses and increase operational efficiency. Such activities, when meshed with improvements in on-farm irrigation water use efficiencies are important water conservation measures. Reductions in the amount of deep percolation losses from farms and conveyance systems can be expected to reduce salt loadings. The effect on salinity reductions will vary according to many factors. Involved would be the nature of the soil and substrata, present water management practices, conditions of the conveyance system, and the natural and artificial drainage conditions.

The studies scheduled will identify the improvement works needed in irrigation systems throughout the Grand Valley, Lower Gunnison and Uintah Basins, the Colorado River Indian Reservation, and the Palo Verde Irrigation District.

Grand Valley. The Grand Valley in Colorado contributes an average of over 700,000 tons of salt annually to the Colorado River. About 76,000 acres are irrigated in Grand Valley. The amount of salt contributed by the irrigated area is unknown, but has been estimated in various studies as being 300,000 to 700,000 tons annually. It has been estimated that an irrigation scheduling and water systems improvement program will reduce the salt contribution by 30,000 to 200,000 tons annually - a potential reduction of 2 to 15 mg/l in concentration at Hoover Dam.

Lower Gunnison. The Lower Gunnison subbasin in Colorado contributes an average of about 1,100,000 tons of salt annually to the Colorado River. About 160,000 acres are irrigated in the subbasin. An irrigation scheduling and water systems improvement program could reduce the salt contribution. The amount of reduction needs to be determined by the feasibility investigation.

Uintah Basin. Drainage from the Uintah Basin contributes an average of 450,000 tons of salt annually. About 170,000 acres are irrigated in the Uintah Basin. Lining the canals and laterals could reduce the salt contribution. The amount of reduction needs to be determined by the feasibility investigation.

Colorado River Indian Reservation. The irrigated lands of the Colorado River Indian Reservation are not yet in salt balance. These lands contribute an average of about 30,000 tons of salt annually to the Colorado River. About 55,600 acres are now irrigated, and this is projected to increase to 99,400 acres by 1980.

Palo Verde Irrigation District. The Palo Verde Irrigation District, a locally developed district, has irrigated about 90,000 acres for many years. In 1970, the irrigated acreage was 91,500 acres which is thought to be near the maximum that will be irrigated in the district. This irrigated land is the major source of return flow to the river between Parker and Imperial Dams. These lands contribute an average of about 90,000 tons of salt annually to the Colorado River.

Point Source Control

Point source control involves salt removal from a localized area contributing an inordinately high salt load to the river system. The principal point source control projects in the program include: LaVerkin Springs, Littlefield Springs, Blue Springs, Paradox Valley, Crystal Geyser, and Glenwood-Dotsero Springs. Within the basin, 28 point sources have been identified and these 6 held the most favorable prospects for achieving the control desired. Among those rejected at this time, based principally on flow-concentration relationships, were Warm Kendall Springs, Steamboat Springs, Jones Hole Creek-Whirlpool Canyon, Pagosa Hot Springs, Havasu Springs, and 17 other small salt load contributing wells, springs, and mine drainages.

Feasibility studies have been scheduled for the six major sources listed. The studies will be carried only as far as is necessary to make a decision regarding the desirability of recommending construction.

The estimated cost for these studies in the 10-year program is approximately $2.5 million. With appropriate authorization and funding, all projects found feasible could be under construction within the 10-year period with several scheduled for construction as early as fiscal year 1975. This presumes that legal and institutional problems of water rights and the Colorado River Compacts are worked out and arrangements made for repayment.

LaVerkin Springs

The LaVerkin Springs study is underway and is scheduled to be completed in fiscal year 1973. Construction could begin in fiscal year 1975 and be completed in fiscal year 1978. These warm springs discharge about 10 cfs into the Virgin River in a reach of about 1,800 feet located 1 mile northeast of Hurricane, Utah. They add a salt load of about 100,000 tons per year to the Colorado River. The spring water contains significant amounts (37 picograms per liter) of radioactivity in the form of radium 226. However, the concentration in the Virgin River at Littlefield, Arizona, in October 1966 was only 0.45 picograms per liter which is lower than the standards set by the Public Health Service for a public water supply. The control could be achieved either by evaporation of the collected waters or by the use of desalting. The evaporation plan might involve the use of from 4 to 10 wells to tap the springs' water source, then conveying the water via a lined channel to an evaporation pond.

An important consideration in these studies will be the loss in water associated with the selected control method. This loss will vary from a total loss of about 8,000 acre-feet per year in the case of the evaporation plan to perhaps as small as 400 acre-feet with some desalting processes. Very preliminary review of the evaporation plan suggests that construction costs could be from $8 to $10 million. The alternative cost of desalting is under study, but cost estimates have not yet been made. Removal of 80 percent of the salt load is expected to reduce the salinity concentration of the river below Hoover Dam by about 6 mg/l and 8 mg/l at Imperial Dam.

Littlefield Springs

The Littlefield Springs discharge along the south side of the Virgin River about ½ mile upstream from Littlefield, Arizona. These springs have a combined outflow of about 10 cfs with an average salinity of about 2,900 mg/1, and contribute an annual salt load of about 30,000 tons to the river system. The disposal of these springs presents a special problem as the outflow is presently collected and used for irrigation in the Littlefield area. This problem, coupled with a general lack of data concerning these springs, dictates the need to approach the study by critically examining the limiting factors to determine the degree of investigative effort required.

Initiation of the feasibility study is scheduled to begin in fiscal year 1974. Removal of the salt load from this source is expected to reduce the salinity concentration by about 2 mg/1 at both Hoover and Imperial Dams.

Blue Springs

The Blue Springs area is located on the Navajo Indian Reservation, Coconino County, Arizona, about 25 miles northwest of Cameron. Spring flow originating from an 11.6-mile reach of the river between miles 3.0 and 14.6 amounts to between 155,000 and 170,000 acre-feet per year with an average annual flow of 161,000 acre-feet or 222 cfs. This is about half the average annual flow of the Little Colorado River. The salt content of the springs averages 2,500 mg/l and adds an annual salt load of 550,000 tons to the river. It is the largest point source in the basin.

The high canyon walls and the inaccessibility of the area cause major difficulties in collecting the spring discharge, desalting, and disposing of the brine. The loss of water associated with desalting would be very important, even with a process that has minimum losses. Exceedingly difficult and costly solutions appear to be involved. Controlling the springs will have a considerable impact on the environment. The Blue Springs are a part of the local Indian folklore. Matters with the Indians and the environment must therefore be evaluated. These engineering, ethnic, and environmental factors will be appraised early in the study. The need for progressing with the study will be continually assessed.

Paradox Valley

It is estimated that Paradox Valley, a collapsed salt anticline, contributes about 200,000 tons of salt per year to the Dolores River. A control project might reduce this salt contribution about 180,000 tons per year. The removal of 180,000 tons per year could reduce the salinity concentration at Hoover Dam about 14 mg/l and 15 mg/l at Imperial Dam.

Previous studies suggest that the control works may include a regulatory reservoir on the Dolores River above Bedrock, Colorado; an evaporating reservoir on the Dolores River in Paradox Valley to evaporate the saline flows from Paradox Valley; a bypass canal to convey the regulated flows of the Dolores River through the valley and around the evaporating reservoir; a West Paradox Creek Diversion Dam; and a West Paradox Creek Diversion Canal to carry the flows of West Paradox Creek around the evaporating reservoir. An estimate of the construction cost would be in the range of $25 to $35 million.

The first year (fiscal year 1972) of investigations will include data gathering, installing gaging stations and ground-water observation wells, and other preliminary fieldwork. The second year (fiscal year 1973) would continue data gathering; map the reservoirs, damsites, and canal alinements; and conduct other fieldwork. In subsequent years (fiscal years 1974 and 1975) the data would be analyzed, a plan formulated, feasibility design and cost estimates made, and a feasibility report prepared. Data gathering would continue through the last 2 years to verify the analysis of the data collected in the first 2 years. The construction period might be from fiscal year 1977 through fiscal year 1980.

Crystal Geyser

The Crystal Geyser results from a gas (carbon dioxide) accumulation blowing water out of an abandoned oil test well at about 4-hour intervals. This geyser spouts about 200 acre-feet of water and 4,000 tons of salt per year which flows west a few hundred feet into the Green River.

The discharge could be collected and pumped to a nearby evaporating reservoir to dispose of most of the 4,000 tons of salt. Removal of 4,000 tons of salt per year would reduce the salinity concentration at Hoover Dam by less than 1 mg/l. During the first year (fiscal year 1972), fieldwork will be accomplished. Designs and estimates would be made and a feasibility report prepared in the second year (fiscal year 1973).

Preliminary appraisals indicate that the control works could include an equalizing reservoir, pumping plant, evaporating reservoir, and a discharge line from the equalizing reservoir to the evaporating reservoir. Estimated construction costs are in a range of $1 to $1.5 million. The project would be scheduled for construction during fiscal years 1975 and 1976.

Glenwood-Dotsero Springs

The Glenwood and Dotsero Springs, located in Colorado, are estimated to discharge about 25,000 acre-feet of water and over 500,000 tons of salt per year. It is the second largest point source in the basin. It is estimated that about 200,000 tons could be removed by collection of the larger flows and desalting or evaporating them. Removal of this salt load per year could reduce the salinity concentration at Hoover Dam about 15 mg/l and 17 mg/l at Imperial Dam.

Investigations are underway for the collection of data. Collection and analysis of data, mapping of the conveyance route and treatment area, other fieldwork, preparation of feasibility designs and estimates would be accomplished in subsequent years with the completion of a report scheduled in fiscal year 1976 or earlier if insurmountable physical or economic problems are encountered.

As now perceived from very preliminary studies, it is anticipated that control works might include a collection system for the saline springs, a conveyance system, and a desalting system or evaporating system to dispose of saline water. Order or magnitude estimates suggest costs in a range of $40 to $60 million. Construction would be scheduled during the period fiscal year 1978-1983.

Diffuse Source Control

Diffuse source control involves salt loading and/or concentration effects that are spread over comparatively large areas such as a minor subbasin. The diffuse source control projects have not as yet been sufficiently studied to formulate more than tentative plans for which rough approximations of costs have been estimated. The tentative plan for diffuse source control projects is to selectively remove the more saline - over 1,500 mg/l - flows and desalting and/or evaporating them. The irrigated areas on these streams would also be investigated to determine if a water systems improvement and management program or an irrigation scheduling and farm management program might reduce the salt load.

Data gathering for the diffuse source control studies are underway. Feasibility studies are scheduled to begin in FY 1974 and continue through FY 1978. Descriptions of these projects are given in the following section.

Price River

The Price River at Woodside, Utah, drains about 1,500 square miles. The flow averages about 74,000 acre-feet per year and contains about 240,000 tons of dissolved solids with concentrations up to 8,200 mg/l.

Selective removal of 50 cubic feet per second during low flow periods could remove about 100,000 tons of salt per year. Removal of this amount of salt may require the desalting or evaporation of about 25,000 acre-feet per year. Removal of 100,000 tons of salt from the river is estimated to reduce the salinity concentration at Hoover Dam about 8 mg/l and 9 mg/l at Imperial Dam.

Data gathering on the Price River is underway and will continue into subsequent years. The feasibility study could begin in FY 1974 and be completed in FY 1977.

San Rafael River

The San Rafael River near Green River, Utah, drains about 1,670 square miles. The flow averages about 95,000 acre-feet per year and contains about 190,000 tons of dissolved solids with concentrations up to 6,400 mg/l. Selective removal of 75 cubic feet per second during low flow periods could remove about 90,000 tons of salt per year. Removal of this amount of salt could require the desalting or evaporation of about 30,000 acre-feet per year. Removal of 90,000 tons of salt from the river is estimated to reduce the salinity concentration at Hoover Dam by about 7 mg/l and 8 mg/l at Imperial Dam.

Data gathering on the San Rafael River is underway and will continue in subsequent years. The feasibility study could begin in FY 1974 and be completed in FY 1977.

Dirty Devil River

The Dirty Devil River near Hite, Utah, drains about 4,170 square miles. The flow averages about 72,000 acre-feet per year and contains an estimated 200,000 tons of dissolved solids with concentrations up to 2,500 mg/l. It is estimated that about 80,000 tons of this salt could be removed which could drecrease the salinity concentration at Hoover Dam by about 7 mg/l and 8 mg/l at Imperial Dam.

Data gathering on the Dirty Devil River is scheduled to begin in FY 1973 and continue in subsequent years. The feasibility study could begin in FY 1976 and be completed in FY 1978.

McElmo Creek

McElmo Creek near Colorado-Utah State Line drains about 350 square miles. However, McElmo Creek also receives return flows from lands irrigated with water from the Dolores River. The flow of McElmo Creek averages about 31,000 acre-feet per year and contains an estimated 115,000 tons of dissolved solids with concentrations up to 3,000 mg/l. It is estimated that about 40,000 tons of this salt could be removed which could decrease the salinity concentration at Hoover Dam about 3 mg/l and 4 mg/l at Imperial Dam.

Data gathering on McElmo Creek is scheduled to begin in FY 1973 and continue in subsequent years. The feasibility study could begin in FY 1976 and be completed in FY 1978.

Big Sandy River

Big Sandy River at the gaging station below Eden, Wyoming, drains about 1,610 square miles. The flow averages about 30,000 acre-feet per year with salinity concentrations up to 2,800 mg/l. However, the flow of Big Sandy River at its mouth is estimated to be considerably larger and also to have a higher salinity concentration. It is estimated the Big Sandy River discharges 180,000 tons of dissolved solids into the Green River. It is also estimated that 80,000 tons of this salt could be removed which could reduce the salinity concentration at Hoover Dam about 7 mg/l and 8 mg/l at Imperial Dam.

Data gathering on Big Sandy River is underway and will continue in subsequent years. The feasibility study could begin in FY 1974 and be completed in FY 1977.

Other Diffuse Sources Considered

Other diffuse sources were considered for inclusion in the program. Blacks Fork and Henrys Fork in Wyoming were considered, but not included as a diffuse source for selective withdrawal because the salinity concentrations exceeded 1,500 mg/l only for short periods each year. Blacks Fork and Henrys Fork will be investigated as a part of the other feasibility studies to determine other methods to reduce their salinity contributions.

Irrigated areas along Upper Colorado River and Roaring Fork have been listed as contributing heavy salinity loads to the Colorado River. Insufficient data are available to determine a method of reducing these contributions. These areas will also be investigated as a part of the other feasibility studies.

VII ALLIED PROGRAMS

The water quality improvement program as described previously may be regarded as one facet of an overall water resource management program of the basin. Water resource development and salinity control are inseparable elements in fostering continued economic growth and development of the resources of the Colorado River Basin.

Salinity control adds another dimension to the preparation of the Western U.S. Water Plan and must be viewed in context with other investigations for augmentation such as weather modification, geothermal resources, and desalting. From such studies, a basin-wide management plan for optimum use of the water resources will evolve.

Western U.S. Water Plan

The Western U.S. Water Plan, referred to as the Westwide Study, is a Level B study of water resource development for the 11 Western States. It was authorized by Public Law 90-537 and includes the specific requirement for providing a plan for the further comprehensive development of the water resources of the Colorado River Basin. As a part of the preparation of that program, augmentation potentials from the fields of weather modification, geothermal resources, and desalting will be evaluated and integrated into the plan. Additional water supplies available through better operational management, conservation, and salvage will be considered. The satisfaction of the international obligations to the Republic of Mexico will also be an integral part of the study.

The augmentation studies are underway and are being scheduled and coordinated through the Westwide Study to provide the most reliable degree of information attainable by 1977 which is the completion date of the study. The Westwide Study would analyze the varied and complex alternatives for development, regulation, and use of all waters of the Colorado River Basin, examine trade offs among alternatives, and recommend priority of future studies and development. Close coordination and cooperation will be maintained between the Colorado River Water Quality Improvement Program and the Westwide Study to assure the preparation of a sound, well integrated plan of development for the Colorado River Basin.

Desalting

To demonstrate the application of reverse osmosis technology to the reduction of salinity at point sources in the Colorado River drainage basin, it is planned to design, construct, and operate a multimodular plant at a site to be determined by investigations now being initiated for completion in fiscal year 1973. The design of this prototype plant would be based on the best reverse osmosis desalting technology available. Design and construction of the prototype plant is scheduled to be undertaken in fiscal years 1974 and 1975. In subsequent years, studies would be made of the application of the technology to specific point source salinity and return flow locations within the Colorado River Basin.

The initial prototype plant would be sized for 15 million gallons per day (mgd). Total capacity needs are estimated at 150 to 200 mgd for installations at specific locations to be established by the investigations. The initial prototype 15-mgd plant is scheduled to be on stream in fiscal year 1975, with the balance of the capacity scheduled to be built in the time period fiscal year 1976 through fiscal year 1979. The initial project would demonstrate the feasibility of desalting high salinity flows in the Colorado River system from a representative source. The acquisition of this technology and experience could then be extended to apply to major point sources of high salinity flows in the system. This program will be a joint endeavor of the Office of Saline Water and the Bureau of Reclamation. Its total cost is estimated at $110 million. To initiate the studies, $200,000 will be available to OSW and $400,000 to the Bureau of Reclamation for work to be undertaken in fiscal year 1973.

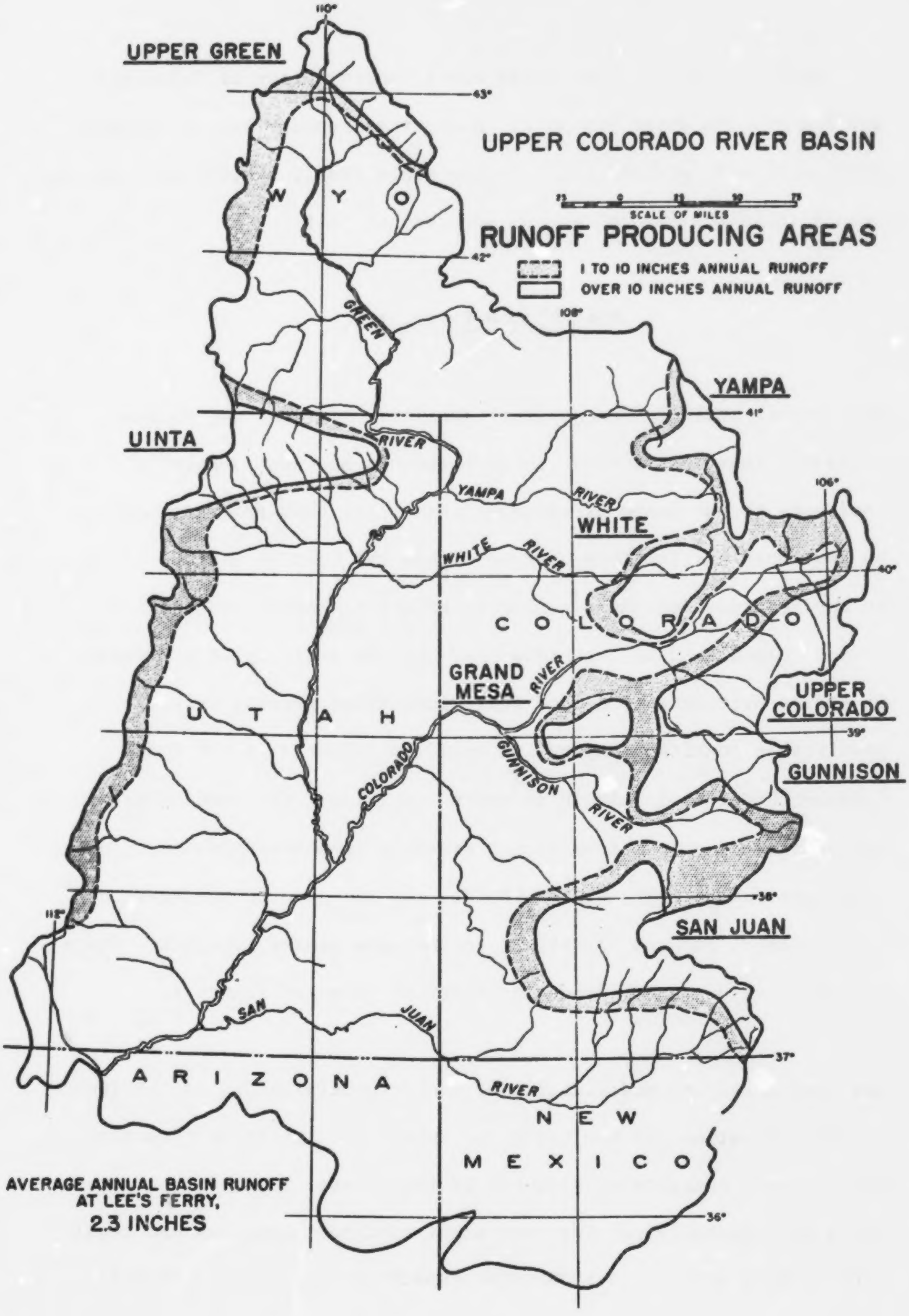
Very significant salt load reduction can be achieved by such a plant particularly if highly saline flows are desalted. Assume, for example, that the feed water has a concentration of 4,000 mg/l and the product water 400 mg/l. Under these conditions, a 150-mgd plant with a 90 percent plant factor would desalt 150,000 acre-ft/year resulting in the removal of 735,000 tons of salt.

Weather Modification

The weather modification program considers only what can be done by 1980. This restriction limits estimates of water supply increases to the scope of reliable capability that can reasonably be developed and feasibly be used within the next 10 years. Given an applied research and engineering effort to refine and confirm present cloud seeding techniques and provide analysis of parameters in storms pertinent to a more fully identified seeding criteria, a justifiable continuous operation could be initated in the Upper Colorado River Basin within 10 years involving: (1) seeding within well-defined and localized target areas by remote-controlled, ground-based generators using silver iodide, and (2) seeding susceptible winter storms at high elevations to increase winter snowpack. There are eight major runoff-producing areas as shown on Figure 4.

Not considered are modification of winter precipitation in the lower and mid-elevations of the basin and summer precipitation throughout the region. Feasible development of these water augmentation potentials will probably require more sophisticated techniques and resolution of more complex environmental aspects than are involved with

Figure 4


UPPER COLORADO RIVER BASIN
SCALE OF MILES
RUNOFF PRODUCING AREAS
▨ 1 TO 10 INCHES ANNUAL RUNOFF
☐ OVER 10 INCHES ANNUAL RUNOFF
UPPER GREEN
UINTA
YAMPA
WHITE
GRAND MESA
UPPER COLORADO
GUNNISON
SAN JUAN
WYO
UTAH
COLORADO
ARIZONA
NEW MEXICO
GREEN
RIVER
YAMPA RIVER
WHITE RIVER
RIVER
COLORADO
GUNNISON RIVER
SAN JUAN RIVER
110°
108°
106°
112°
43°
42°
41°
40°
39°
38°
37°
36°
AVERAGE ANNUAL BASIN RUNOFF AT LEE'S FERRY, 2.3 INCHES

high elevation winter seeding. Continued improvement of the techniques assumed available by the mid-1970's and development of completely new methods represent speculative possibilities for further enhancing basin water supplies through weather modification.

In a limited water area, such as the Colorado River Basin, producing about 2 million acre-feet of usable new water annually could be a significant contribution toward salinity improvement. The highly favorable benefit-cost ratios; the flexibility of use, largely with existing water and power systems; and the opportunity for obtaining even greater new water yields with advanced techniques point to weather modification as a very desirable tool for water resources management. The Upper Colorado River Basin will be one of the first regions where a reliable, optimized capability to increase precipitation could be developed on a region-wide basis. It is believed that firm, acceptable answers and workable systems can be successfully achieved within 10 years.

Geothermal Resources

The potential of geothermal resources for water production is currently under investigation by the Bureau of Reclamation and the Office of Saline Water. Successful development could provide an additional source of water. The geothermal water could be meshed into the overall water management system to assist in achieving salinity control, particularly in the lower reaches of the system.

The Bureau of Reclamation and Office of Saline Water are actively engaged in a joint geothermal resource investigation program in the Imperial Valley, California. Following more than 3 years of geophysical investigations, coupled with shallow exploratory drilling (to 1,500 feet), the first deep well capable of producing hot steam and brine will be drilled late in fiscal year 1972. The well will be located in the East Mesa area of Imperial Valley and drilled to a depth of 4,000 to 8,000 feet. A portable pilot desalting plant will be moved to the well site and test operations for desalting geothermal brines will start. Also, a test disposal well will be drilled in July 1972 to determine the feasibility of reinjecting the byproduct fluids from geothermal development.

Preliminary studies indicate the Imperial Valley geothermal resources might be capable of producing up to 2,500,000 acre-feet of fresh water per year on a sustained basis as well as large quantities of electric energy with possible mineral byproduct recovery.

Operation and Maintenance Activities

Various facets of the Bureau of Reclamation's operation and maintenance activities deal directly with salinity problems in the

Colorado River. Water quality studies are continuing in the basin as required under various public laws, and biennial reports are made to Congress. These reports are prepared in cooperation with the Geological Survey, and include data regarding historical, present modified, and anticipated future chemical quality of water conditions at 17 key stations in the Colorado River Basin. Also presented are discussions of State water quality standards, quality control, sources of salinity, sources of other forms of pollution, and other aspects of water quality in the basin. In fiscal year 1972, $90,000 will be used in prosecution of this program.

Consumptive use studies are being undertaken as required by Section 601 of the Colorado River Basin Project Act. These studies will provide useful input to prosecution of the salinity control program. In fiscal year 1972, $100,000 is being expended for this activity.

Water Quality Prediction Investigations

A cooperative study is underway between the Bureau and EPA to develop a technique for predicting more precisely than now possible the mineral quality of irrigation return flow. The means for accomplishing this will be through the use of mathematical models and high-speed computers. The mathematical model is primarily a mathematical formula or expression attempting to duplicate conditions encountered on an irrigation project. The study utilizes data from existing irrigation projects in order to verify the technique.

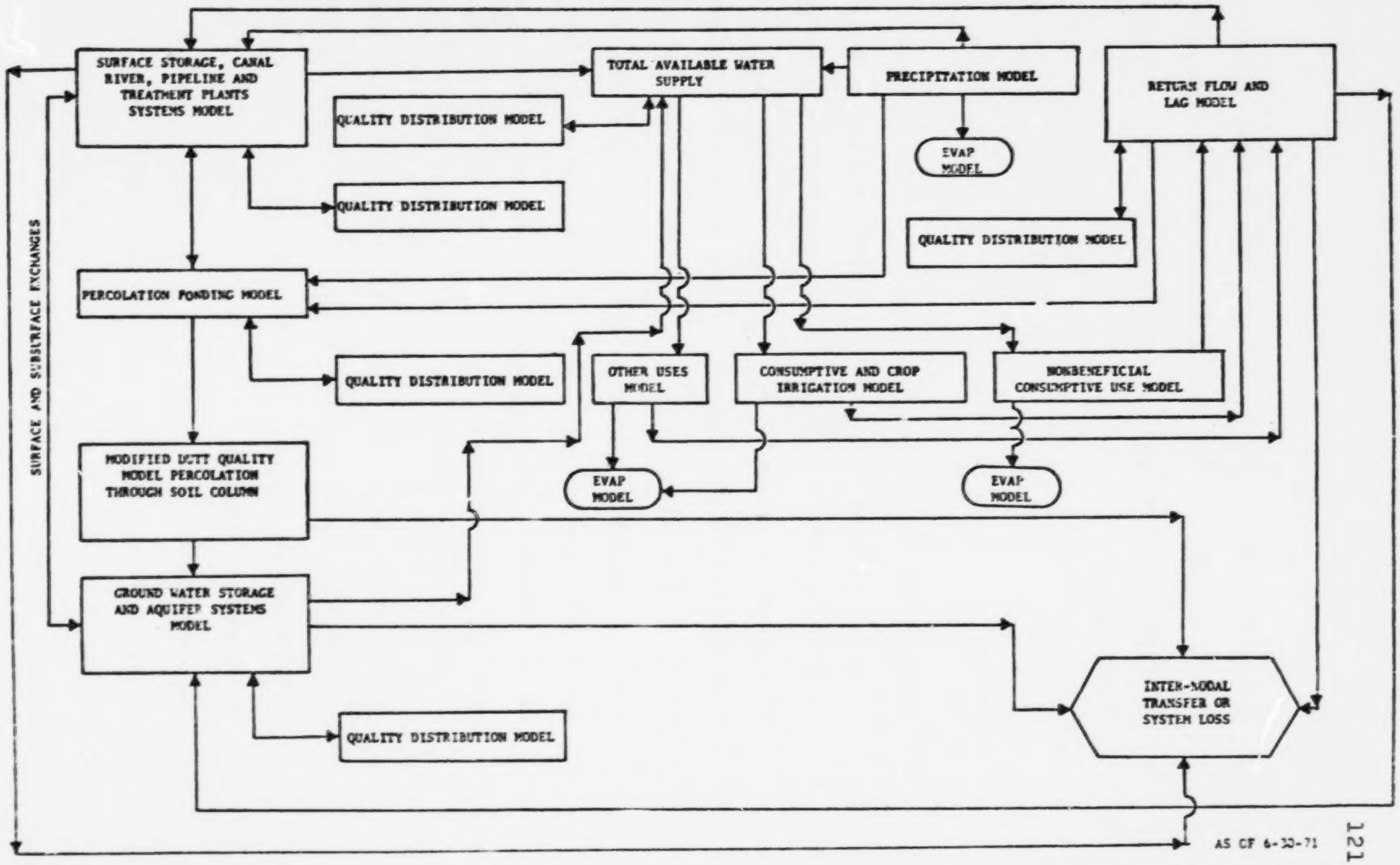
The objective of the study is to use a model in predicting changes in capacity and the associated water quality distribution of the aquifer and also the quality distribution of the water as surface effluents from the system. The prediction of the system responses was compared with the historical data, both quantity and quality distributions as a measure of the reliability of the model. Data from the Vernal Unit of the Central Utah Project have been used for designing and testing the model. Further tests will be made using data from the Grand Valley area in Colorado and the Cedar Bluff Unit in Kansas.

Although model testing and development of all the mathematical submodels is not complete, it appears at this point that a satisfactory model has been designed to predict the mineral quality of return flow from irrigation projects. Completion of the submodels will extend capability to impact analysis, optimization, and best plan selection. The simulation submodel is depicted in Figure 5.

The implication for water resource projects is that farm operation could be designed to use the least amount of water, return the smallest amount of salt to the river and permit the farmer to

Figure 5

HYDROLOGIC SYSTEM FOR SIMULATION SUBMODEL


SURFACE STORAGE, CANAL RIVER, PIPELINE AND TREATMENT PLANTS SYSTEMS MODEL
TOTAL AVAILABLE WATER SUPPLY
PRECIPITATION MODEL
RETURN FLOW AND LAG MODEL
QUALITY DISTRIBUTION MODEL
EVAP MODEL
QUALITY DISTRIBUTION MODEL
QUALITY DISTRIBUTION MODEL
PERCOLATION PONDING MODEL
QUALITY DISTRIBUTION MODEL
OTHER USES MODEL
CONSUMPTIVE AND CROP IRRIGATION MODEL
NONBENEFICIAL CONSUMPTIVE USE MODEL
MODIFIED DUTT QUALITY MODEL PERCOLATION THROUGH SOIL COLUMN
EVAP MODEL
EVAP MODEL
GROUND WATER STORAGE AND AQUIFER SYSTEMS MODEL
INTER-NODAL TRANSFER OR SYSTEM LOSS
QUALITY DISTRIBUTION MODEL
SURFACE AND SUBSURFACE EXCHANGES

AS OF 6-30-71

obtain the greatest possible return from his farm. Using this model, the salt load reductions expected from irrigation scheduling and management will be verified on the Vernal Unit in the Uintah Basin.

Research

Considerable research will be required to support the water quality improvement program in the basin. Ongoing and scheduled research which is expected to find application in the salinity control effort now underway or scheduled by the Bureau of Reclamation includes: (1) prediction of the quality of return flows (in cooperation with EPA), (2) mathematical model for predicting nutrient and salt loadings, (3) ecological considerations in project planning, (4) wastewater reclamation opportunities, (5) case studies of desalting for salinity control, (6) management of saline waters, and (7) testing advanced irrigation systems.

In addition to the foregoing research, considerable additional research ought to be performed to assist in implementing a viable salinity control program. The Office of Water Resources Research is supporting activities in this area, and it is anticipated that the Environmental Protection Agency will join in financing such research efforts. The land grant universities and the Agricultural Research Service of the Department of Agriculture should also have important inputs.

Some of the kinds of work needed are field trials of water harvesting techniques, developing special uses for water of inferior quality; reducing costs of achieving high irrigation efficiencies; identifying field relationships of irrigation efficiency to return flow quality under specific soil and geologic conditions; studies of water flow through large impoundments including the chemical reactions and velocity of throughput of the dissolved constituents; vegetative management techniques particularly as related to phreatophytes with the aim of reducing water use and protecting the breeding areas of birds and other wildlife; identification of watershed management and salinity output relationships; further studies into the economics of water quality; and ecologic considerations involving salinity effects on aquatic life and other biological systems; recovery and extraction of minerals from brines; development of better inland brine disposal techniques; identifying opportunities for using reclaimed waste water to satisfy outdoor recreation needs; and identifying opportunities for using heated water from desalting installations to extend the recreation season for swimming and other activities.

MR. MALETIC: Of course I have no intention of reading the entire report. I will brief a few highlights--there might be a few people here who haven't been through the report--and show two slides. EPA has suggested that about a 15-minute presentation would be desirable and I think I could do that within that time limit.

I will drop these two slides in and I will ask to have someone operate this machine for us.

(Off the record.)

MR. MALETIC: The Bureau of Reclamation has structured a comprehensive 10-year Water Quality Improvement Program integrated with programs involving weather modifications, geothermal resources, desalting, and the Western U. S. Water Plan. These programs, when implemented, could maintain salinity in the lower main stem at or below present levels.

The Water Quality Improvement Program has an investigation and an implementation phase. The authority for the investigation is derived from public laws relating to the Colorado River storage project and participating projects, the Navajo Indian Irrigation Project and San Juan-Chama Project Act, and the Fryingpan-

Arkansas Project Act, respectively.

Feasibility studies would be initially performed on a total of 16 irrigation, point, and diffuse salinity sources with related basinwide planning involving development of a mathematical model of the Colorado River, economic analysis of water quality, analysis of legal and institutional matters, and the investigation of potentials for improving water quality at points of diversion.

Early emphasis is being placed on those activities most likely to achieve water quality improvement at least cost. Construction of a mathematical model may reveal better ways to operate the river system to generate water quality benefits without incurring capital investment costs for structural control measures. Irrigation source control, involving close integration of on-farm irrigation water scheduling and management, with water systems improvement and management, is expected to significantly reduce salt loadings. Some measuring devices may be required to implement the irrigation scheduling and management program which is now being implemented. This can be expected to achieve early benefits at minimal cost.

J. T. Maletic

Following the full operational establishment of the irrigation scheduling activity, water users would be expected to operate the program. This could be contractually tied to water systems improvements and the related cost-sharing arrangements with the irrigation districts or other entities involved. The irrigation scheduling and water systems improvement activities need to move together along with parallel improvements of on-farm irrigation systems, the latter to be done primarily through private investment with technical assistance from the Soil Conservation Service and some financial aid from the Rural Environmental Assistance Program.

The specific Water Quality Improvement Program elements and the fiscal years during which the work is presently scheduled to be accomplished will be shown on the first slide.

This, then, is the program as we have structured it at the present time. If you will look at the bottom, we are currently working on a mathematical simulation model of the Colorado River. This simulation will be completed at the end of Fiscal Year 1973 and the mathematical model has five blocks in it. The first block is a data analysis block. That portion of the model is nearing completion. This will be followed by a simulation block, then an impact and sensitivity block, an optimization submodel, and finally a dynamic model which would give us guidance for making decisions on the river as a whole.

Economic evaluation of water quality is presently under way. Contracts have been advertised for and some of these studies will be negotiated with outside sources and with some inside studies within the Bureau before the end of this current fiscal year.

Institutional and legal analyses will be conducted from 1972 through 1973.

And then we are studying ion exchange process systems as an alternate to the other methods of salinity control which are shown. In this particular study a small pilot plant is being set up in the Colorado River to study the feasibility of the process of product water, the problems, the salt output, and so forth.

Irrigation scheduling and management work is now under way on Grand Valley and starting in subsequent fiscal years work will be under way in the Lower Gunnison Basin, Uintah Basin, the Colorado Indian Reservation, and the Palo Verde Irrigation District. Contacts have been made with the Board of Directors of the irrigation districts in the area, a computer program for conducting the scheduling work has been rewritten to fit a CD-31 computer, and field work is under way and other contacts to get that program moving.

Water systems improvement and management work involves rehabilitation of irrigation systems. Some of these studies will be starting this fiscal year with the work continuing through 1976. The same areas involved in the irrigation scheduling and management will be involved in the water systems improvement and management programs.

Point source control work is under way now at LaVerkin Springs. Drill crews are presently at work drilling out and determining the geology, direction of flow path and feasibility of capturing the saline flows from the spring.

Work is under way at Paradox Valley. Contracts have been let for mapping contours, resistivity. Studies are under way to locate salt and salt transfer points within the aquifer and alternate means of collecting the salts are being studied.

At Crystal Geyser, work will be under way there with Brigham Young University and the contract is in the process of being executed with them.

Studies are under way on Glenwood-Dotsero Springs to identify the numerous sources where these particular streams come into the river and to better analyze the problem before we move towards developing control plans.

Investigations in 1973 and subsequent years will be under way at Blue Springs, the major natural source of salinity currently identified in the program, and also beginning in 1974 work will be done on Littlefield Springs.

Diffuse source control projects. Very little basic data is available on these diffuse source control projects. Therefore, current effort is in the direction of establishing gaging stations. The work has already been accomplished with the U.S.G.S. Several gaging stations have been put in on these remote streams. Others are scheduled to go in before July 1. And you see a different color up on the chart there. That indicates a data and analysis block, because there is so little information currently available on these particular sources that we cannot begin to develop a comprehensive salinity control plan for these large areas until we have a reasonable set of data from which we can work. So that work will be under way. And then in subsequent fiscal years, as you can see, beginning on Price River in 1974 and Big Sandy River in 1974, we will be into the actual feasibility studies.

That, then, covers the structure of the program as we now stand.

Associated with this program we have very important allied programs, including weather modification, desalting, geothermal resources, research, and the Western U. S. Water Plan. Weather modification research now under way is expected to develop, by 1980, a reliable and workable system for increasing precipitation. The Upper Colorado River Basin will be one of the first areas where regionwide applications could be made. It is estimated that up to 2 million acre-feet of new water could be added to the river system and this would serve to significantly improve the salinity levels.

Desalting will initially involve the installation of a research and development prototype facility using the reverse osmosis process. The prototype plant would have a capacity of 15 mgd and could be expanded to 150 mgd or more. The facility would be located in the lower reach of the river. If expanded to a capacity of 150 mgd, the salinity levels in the lower reach would be greatly improved. This would be a cooperative effort between the Office of Saline Water and the Bureau of Reclamation.

Geothermal investigations are now being conducted by the Bureau of Reclamation and the Office of Saline Water. These investigations could ultimately lead to additional sources of water. This water could be fitted into the overall river basin management plan to achieve further improvements in water quality.

Research is under way or scheduled which would provide valuable inputs to the salinity control effort. Included is such work as developing better predictions of irrigation return flow quality, deriving systems for assessing ecologic impacts of water resource projects, developing procedures for management and use of saline water, testing advanced irrigation systems, and identifying wastewater reclamation opportunities.

It will be the responsibility of the Westwide study to present the varied and complex alternatives for development, regulation, and use of all waters of the Colorado River Basin, examine tradeoffs between alternatives, prepare plans and cost estimates, and recommend priority of future studies and development. Close coordination and cooperation will be maintained between the Colorado River Water Quality Improvement Program and the Westwide program to assure the preparation of a sound, well integrated plan of development for the Colorado River Basin.

Implementation.

Assuming all projects now under investigation or scheduled to be investigated are implemented, the program is expected to involve capital expenditures in the order of magnitude of $400 to $500 million. These costs are to be shared with beneficiaries. Therefore, an essential feature of the feasibility studies and the related basinwide studies will be to develop equitable cost sharing and repayment formulas. New institutional arrangements may be required not only as related to cost sharing and repayment, but also to the operation and maintenance of the constructed facilities. The urgency of the salinity conditions in the lower reach makes it imperative that movement from the study to the construction phase be expedited. This could be done for individual projects within a period of 1 to 2 years following completion of a favorable finding of feasibility. In the interim, as previously stated, some salinity improvements can be anticipated through alteration of river operations using the mathematical model and from the irrigation scheduling and management activities.

Effects of the program.

The average annual salinity concentration of the Colorado River at Imperial Dam during the period 1941 to 1968 was 751 mg/l. That is the historic concentration. The annual salinity concentrations during this same period have ranged from a minimum of 649 mg/l in 1949 to a maximum of 918 mg/l in 1956. The monthly salinity concentrations of the Colorado River at Imperial Dam during the period 1941 to 1968 have experienced an even wider range from a minimum of 551 mg/l in December 1952 to a maximum of 1000 mg/l in January 1957.

Levels of salinity concentrations presently found in the lower Colorado River vary, depending on the type of period used to describe that level. And as indicated above, the average for a year is greater than the level during the period 1941 to 1968 and the peak monthly concentration is even greater than the level for a particular year.

To depict effects of the water quality improvement and allied programs, a table was prepared showing the projected reductions in salinity concentrations for each program and the estimated effects on the synthesized salinity levels at Imperial Dam.

Slide 2, please.

This, then, is the impact anticipated of the program, without a control program, as we could see, the estimated salinity level using what we call present modified flow conditions, which cover the period 1941 to 1948, with all developments currently operating cranked back into this historical set of data so that their effects are reflected. Therefore, the difference between the 865 that you now see and the 751 previously reported. So using that, present modified flows are data based, no salinity control program, the projection is a general increase in salinity to the year 2000 up to 1,250 ppm without a control program.

Now, because of the variations and vagaries of flow in the river caused by climatic conditions and other factors, the mean salinity value given as a figure you will never get, that is an average, and, therefore, we felt it important to show the range around which that mean could be expected for the range within which the mean resides. And that is indicated and shows that in 1970 that range was about 750 to 1,060 mg/l.

With all programs operating, both the Water Quality Improvement Program and our allied programs, reductions in the order of 120 mg/l by 1980, 355 by 1990, and 405 by the year 2000 are anticipated, and on this basis, as shown on the bottom line, salinity would be maintained at or below present levels with in the year 2000 the concentration estimated to be about 845 with a range of 675 to 1,125.

Now, we recognize that the program as currently structured is based on reconnaissance data and, therefore, we are setting into motion as part of the exercise in this program the critical appraisal of progress and direction, which will be done every 2 years, and the factors to be included in that appraisal will be the kinds of physical works needed, the economic viability of the proposed control works, public acceptance and commitment to the proposals, potential impacts of evolving technology, and the relationships within the basinwide management plan.

Thank you, Mr. Chairman. That is the summary of the report.

MR. STEIN: Thank you, Mr. Maletic.

I would like to congratulate you and your Department for getting out this report in time - just when you said you would. We are all very appreciative, indeed, for your accomplishing that.

Are there any comments or questions?

Yes.

MR. O'CONNELL: John, on the table that you showed there, the values for the various years typical to the program reductions, would that reflect the time of 2 or 3 or 4 years, or whatever it is, it takes for these improvements, for their effects to be felt at Imperial Dam, or is it strictly a calculated figure?

MR. MALETIC: No, that is a calculated value. And in making that calculation, when we set up the time frame, we allowed 4 years for the through-put of water through our large holdover storage reservoirs, which would be Glen Canyon and Hoover, and there will be work done to see how long it takes an ion to move through these large reservoirs and come out.

So those figures reflect about a 4-year period and certainly more study needs to be done on that, but as well as we can do it, it is in there and those are reconnaissance estimates.

MR. O'CONNELL: It does reflect that--

MR. MALETIC: It reflects the time period, yes.

MR. O'CONNELL: So if you calculated without taking that into consideration--

MR. MALETIC: There would be another 4-year--you would have to move it back 4 years.

MR. STEIN: Are there any other questions?

MR. DICKSTEIN: John, in the document you briefly referred to several projects that could be accelerated, correct?

MR. MALETIC: Right.

MR. DICKSTEIN: What is the overall effect of these accelerated projects? Maybe I shouldn't say accelerated projects. Projects that you could--

MR. MALETIC: Yes, we have considered this, Mr. Dickstein. The principal projects that could be accelerated would be La Verkin Springs, Paradox Valley, and Grand Valley, and we are at work, as I indicated in my report, on each of those at the present time. If those projects are accelerated, our current estimates are that we could probably remove about 400,000 tons of salt out of the river system with those projects.

MR. DICKSTEIN: Thank you.

MR. STEIN: Any other comments or questions?

MR. (UNIDENTIFIED): Yes, I might ask one.

If those projects were accelerated in that manner, would that change the figures in the table of your report to, say, 1980?

MR. MALETIC: For the time? Yes, probably that would result in some change in our estimates in the table because that would be accelerated--that assumes compressing the entire program, removing the usual administrative procedures that we need to go through, plus the congressional action that we would go through to get projects authorized, funded, and so forth. All of that would need to be compressed to achieve that kind of a reduction within a 5-year period. Those effects, then, projects could be built by 1977 and that would give us 3 years, the effect of Hoover is in there, 2 years to go through Powell, which wasn't in the data, and by 1980 you would have those effects. So that our table would be close. I would have to say that it would be close.

And the other thing that I would like to point out, on an accelerated basis, Grand Valley would involve the rehabilitation of some 76,000 acres, mining ditches, canals, making arrangements with water users. If difficult problems of consolidating ditches or anything like that would arise, these are really difficult negotiating questions and I would like to state and make it clear and without any equivocation that Grand Valley probably could not be completed by 1977, but we could go a long way towards moving in that direction. A lot depends on the cooperation received from the many irrigation districts in the area. You have to work with these people as entities. They must be convinced of the value of the program to them and that this would be a profitable and a correct thing for them to do.

MR. STEIN: Any other questions or comments?

If not, thank you very much.

MR. MALETIC: Thank you, Mr. Chairman.

MR. STEIN: Does anyone else want to add anything? Because we are going to ask the conferees for conclusions and recommendations if we possibly can get them.

If not, I will call on Mr. O'Connell. Do the Federal people have any suggestions on where we are going to go?

By the way, for this session, in effect, we are going to operate as in an executive session. Now, any of the conferees here, Federal or State, wishing to call upon consultants or colleagues who are sitting in the audience, just feel free to do so and have them either come up or make their comments.

Mr. O'Connell, would you go ahead?

MR. O'CONNELL: As you recall, at the first portion of this session, Mr. Chairman, the States entered into the record their position on a number of issues, the unanimous position, and at that time we made the comment that we were in agreement in principle with their statements, but that we wanted to expand upon it and possibly modify it in certain ways so that we could be in full agreement with it.

We have since done that and have prepared a set of proposed conference recommendations, which I have here and will read.

These are, as will be clear, patterned very closely after what the States' position has been, and wherever possible we used identical language so as to minimize any potential differences. So if it is agreeable with you, I will read the proposal that we have for their consideration.

Our proposed conference recommendations are:

I. It is recommended that:

A. A salinity policy be adopted for the Colorado River system that would have as its objective the maintenance of salinity concentrations at or below levels presently found in the lower main stem.

B. In implementing the salinity policy objective for the Colorado River system, the salinity problem be treated as a basinwide problem that needs to be solved to maintain Lower Basin water salinity at or below present levels while the Upper Basin continues to develop its compact-apportioned waters.

II. The salinity control program as described by the Department of the Interior in their report entitled, "Colorado River Water Quality Improvement Program," dated February 1972, offers the best prospect for implementing the salinity control objective adopted herein. Therefore, it is recommended that:

A. To guard against any rise in salinity in the river, a salinity control program, generally as described in the Interior Department report, be implemented on an accelerated basis.

B. The Bureau of Reclamation have the primary responsibility for investigation, planning and implementing the basinwide salinity control program in the Colorado River system.

C. In order to expedite the salinity control program, it is recommended that the Bureau of Reclamation reschedule the implementation of selected projects as shown in accordance with the following schedule. The objective of this recommendation is to initiate needed corrective action immediately on the problem of salinity control and to achieve a stabilization of salinity levels on the lower Colorado River at the earliest possible date. And this schedule of projects would be:

1) Grand Valley, which would be expected to achieve a salinity reduction of 140,000 tons per year and have the effect of reducing the salinity concentration at Imperial Dam by 11 ppm. It would be initiated in 1972 and completed in 1977.

2) The second project would be La Verkin Springs. A salinity reduction of 80,000 tons per year and reduction in the Imperial Dam salinity of 8 ppm, initiation in 1972, completion in 1977.

3) Paradox Valley to have a reduction of 180,000 tons per year, reduced salinity in Imperial Dam by 14 ppm, be initiated in 1972 and completed in 1977.

For a total salinity reduction

of 400,000 tons per year and a reduction of salinity at Imperial Dam of 33 ppm.

D. The Office of Saline Water contribute to the program by assisting the Bureau of Reclamation as required to appraise the practicability of applying desalting techniques. And

E. The Environmental Protection Agency continue its support of the program by consulting with and advising the Bureau of Reclamation and accelerating its on-going data collection and research efforts.

III. To achieve the salinity policy adopted herein, the long-range program objectives of the Bureau of Reclamation shall achieve the following levels of salinity control.

The projected salinity levels at Imperial Dam, full development no control in 1970, would be 865 ppm. The projected effective control in that year would be zero and the projected effect with controls would be unchanged, 865 ppm.

Projected salinity level at Imperial Dam, full development with no control 1980, would be expected to be 1,000 ppm. The projected effective control would be 120 ppm and the projected effect with controls would be 180 ppm.

In 1990 the three figures would be 1,200, the effective control would be 355 ppm, and the projected effect with controls 845 ppm.

In the year 2000 the figures would be 1,250 ppm with no control, the effective control 405 ppm, the projected effect with the controls 845 ppm.

IV. It is also recommended that in all future water resource development projects feasible salinity control measures integral to the projects shall be provided.

That concludes the suggestions that we would like to make as possible conference recommendations.

MR. STEIN: Do the States have any comments?

Mr. Rozich.

MR. ROZICH: Yes. As you surmise, the conferees present did meet and go over the proposal of conclusions and recommendations as submitted by the EPA. I think we are in very close agreement with what EPA proposes. However, we have suggested some changes and possibly the best way would be to read through it and maybe I can outline the changes as we go through.

MR. STEIN: Yes. Why don't we start with I, sub 1.

MR. ROZICH: Essentially, Roman numeral I, we suggest that sub 1 and sub 2 be combined, making this one long paragraph.

MR. STEIN: Is there any objection to that? By putting a period after "stem" including the next in the next sentence, if that is all right?

All right. Let me get this and I know you are going to have to consult, so let's get it exactly right.

MR. MALETIC: Mr. Stein, we are in the process of making 25 copies of this.

MR. (UNIDENTIFIED): All we have right now are--

MR. STEIN: I know, but let's do this.

It will read: "A salinity policy," period, keep on the paragraph and start the next sentence with "in" and we are all set. All right?

MR. ROZICH: They have after "lower main stem"--"and in implementing the salinity policy."

MR. STEIN: Where is that?

MR. ROZICH: In the first paragraph and after "stem" put "and."

MR. STEIN: "And"? You want "and"?

MR. ROZICH: Yes.

MR. STEIN: All right.

MR. ROZICH: The rest of it is the same.

MR. STEIN: All right. Is that agreed? That is an awfully long sentence.

All right.

MR. ROZICH: Roman numeral II, we suggest after "Colorado River Water Quality Improvement Program" we put "dated February 1972."

MR. STEIN: All right. Wait a minute. Just agreed, "dated"--

MR. DICKSTEIN: We already made that statement.

MR. STEIN: No, no. If we can get agreement let's just do that. Let's just agree.

O. K.

MR. ROZICH: Arabic numeral 1 under this, we recommend deleting the first clause and it would start, "a salinity control program, generally as described in the Interior Department report, be implemented on an accelerated basis."

MR. O'CONNELL: We could just take that under advisement.

MR. STEIN: All right. Let's put--

MR. ROZICH: Arabic numeral 2 we left the same.

Number 3, we did change it considerably, but left, I think, the intent the same way. I will read it as we have it.

> To expedite the salinity control program, it is recommended that the Bureau of Reclamation and the Environmental Protection Agency assign a high priority to the La Verkin Springs, Paradox Valley, and Grand Valley water quality improvement projects as demonstration projects, with the objective of achieving stabilization of salinity levels on the lower Colorado River at the earliest possible date. The contemplated impact of the action is the early removal of 400,000 tons of salt from the river system, resulting in an estimated average annual reduction in the salinity concentration at Imperial Dam of 30 mg/l.

MR. O'CONNELL: Is that 30?

MR. ROZICH: Thirty-three. Excuse me. It

should read 33.

MR. STEIN: Do you want to read that four hundred--do you have four hundred--

MR. ROZICH: Four hundred tons of salt--"early removal of 400,000 tons of salt from the river system resulting in an"--

MR. STEIN: You mean 400,000 tons per year, don't you?

MR. DICKSTEIN: Per year?

MR. ROZICH: Per year.

MR. STEIN: All right.

MR. ROZICH: And you have the rest of that.

MR. STEIN: All right. Do you have any comment? All right, we will think about that one.

MR. ROZICH: Arabic number sub 4 and sub 5 we left the same.

With regard to Roman numeral IV, we suggest the following change--

MR. HUME: III.

MR. ROZICH: Or III.

> It is recognized that adoption of numerical criteria should be deferred until the potential effectiveness of

Colorado River salinity control measures is better known. However, to achieve the salinity policy adopted herein, the salinity control program of the Bureau of Reclamation shall be directed towards achieving, as a minimum, the following reductions in salinity at Imperial Dam.

And for 1980, reduction of 120 mg/l.

For 1990, a reduction of 355 mg/l.

For the year 2000, 405 mg/l.

If this reduction is achieved, the Bureau of Reclamation has estimated that the following would be the ranges of salinity at Imperial Dam.

Estimated salinity level in milligrams per liter, full development without control and then with control, for 1980 the range would be 860 to 1,220, and with the control program it would be 740 to 1,100.

1990, without control 1,040 to 1,470; with control 685 to 1,115.

The year 2000, without control 1,080 to 1,530; with control 675 to 1,125.

Essentially it is taken out of the table.

The underlying bases in development of the reductions in salinity and estimated projected ranges of salinity levels are found in the Department of the Interior's report entitled 'Colorado River Quality Improvement Program' dated February 1972.

That is our proposal.

MR. STEIN: O.K.

MR. ROZICH: And with regard to Roman numeral IV, we felt that this was essentially contained in the rest of the conclusions and recommendations and it is really not necessary.

MR. STEIN: Well, all right.

I think probably we may have to wait on you, but we will recess and have you come back and go over these. Let me say, other than technical points, I think again we have that one major point that maybe you are all going to have to think out, and I hope come to some conclusion. That is, the basic suggestion that calls for putting in or the adoption of numerical criteria be deferred until potential effectiveness of Colorado River salinity control measures is better known. And the last time, if you recall, I think Mr. Armstrong and the Bureau of Reclamation indicated that the Bureau would be permitted to come up with a recommendation in about 3 years, did they say, or what, 2, something?

MR. MALETIC: Two to three years.

MR. STEIN: Two to three years, for some time.

The question here is, if we are adopting the Bureau of Reclamation program, whether the determination should not be to give full credence to the recommendation and they come up with it and see where we go from there rather than make these determinations here. And I think that is the key point.

I ask the States to think of that, because I think we have a recommendation and an offer from the Bureau of Reclamation. If they are going to come up with that in the period of time that Mr. Armstrong said they were, from where we sit, we are probably going to have to be in a position to consider it. I am not sure that that is any different than what you said, but that would at least fit in with the Federal-State program.

I ask you to think that over, because other than that I think there are technical problems.

How soon do you expect to have this duplicated?

MR. MALETIC: Shortly.

MR. ROZICH: We are waiting for it now.

MR. STEIN: All right. I am not sure our people can respond right now. I do think, what I am going to have to do, is call a 15-minute recess and hopefully if that material is done--

MR. ROZICH: California has a statement they would like to--

MR. STEIN: Just a moment.

MR. MALETIC: Before you recess I would like to clarify this 2 or 3 years and put this in the precise context that Mr. Armstrong read.

He said, "A Federal-State task force should be appointed to provide guidance and to participate in the effort. The task force should be allowed 3 years to complete the work, to complete its findings, and to make recommendations..." To make recommendations. Now, since then--

MR. STEIN: That is what I said.

MR. MALETIC: "...to make recommendations to another session of this conference."

MR. STEIN: That is correct. I thought I said that.

What I would suggest we do is to consider the Bureau of Reclamation offer, set up the task force to get the recommendations, and consider where we go with those recommendations rather than this--I think we are very close, but I think possibly you can accommodate to that.

MR. HUME: Mr. Stein, the States also considered another matter this morning. I think that it is not our thought that it go in the resolution. However, it would be appreciated if it could be included as part of the record of these proceedings, and I read:

> We want to emphasize that the Bureau of Reclamation's program as submitted in its report 'Colorado River Water Quality Improvement Program,' dated February 1972, and on which the conference recommendation No. III is based, should be considered as an open-ended and flexible program. If alternatives not yet identified prove to be more feasible, they should be included as part of the program, and if

elements now included prove to be infeasible, they should be dropped. In addition, it should be recognized that there may be other programs which could reduce the river's salinity. Since present levels are greater than desirable, we are hopeful that additional programs will eventually be developed in order to obtain lower salinity levels.

The February 1972, report states that the USBR Mathematical Simulation Model for the Colorado River system will be used to evaluate the Water Quality Improvement Program. This will be an important tool to evaluate the program's progress. The results of this evaluation along with the general program progress should be reported annually to the conferees and other interested State agencies.

MR. STEIN: Do all the States agree with that, as far as you know? I know you can't-- All that are here?

MR. ROZICH: Yes.

MR. STEIN: Do all of them who are here agree with it?

MR. WILLIAMSON: That is not a conferees'--

MR. STEIN: No.

MR. WILLIAMSON: I mean this is a State position and any conferee can make his own statement, just a statement.

MR. STEIN: I know, but why don't you want to accept it?

MR. WILLIAMSON: We have no objection. I say rather than being a part of this resolution or anything, it is a position statement and any State can make their own position statement.

MR. STEIN: O. K.

MR. (UNIDENTIFIED): Just as well agree to it.

MR. WILLIAMSON: Yes, agree to it.

MR. STEIN: No, no, here is what I was suggesting--and I don't know if the conferees want to do it and I don't know that I see a Federal objection to that from the conferees I have here--that might be a useful thing to put as a footnote to III. In other words, it is an explanation. Because I think essentially what we are doing here, and it is a very good thing, you can only set out a program like Grand Valley, La Verkin Springs, Paradox Valley; they may or may not pan out. We think they are going to pan out. If it doesn't work, we should indicate we are flexible and we are going to pick up another project. I think that might be a useful thought. You might want to consider taking that statement and we can footnote that to III, just add it to the conclusions and recommendations.

Is that agreeable?

MR. (UNIDENTIFIED): That is agreeable.

MR. STEIN: O. K.

Are there other comments?

Well, if not, let us recess and look this thing over to determine if we have any other thoughts and try to get those other figures down and see if we can have them. Hopefully we should be able to reconvene in 15 minutes.

(RECESS)

MR. STEIN: Let's reconvene.

Let me give you this the way I see it so we can all put our minds to this as we go along.

I am not sure, but from eavesdropping in on the

Federal caucus (laughter), that we can--John Chancellor got that great job that he's got and look what happens to me (laughter)--I have the conviction that at least the draft recommendations may be such that they will not be readily resolved this afternoon. I think the conferees, the States and the Federal people, are very close together, and I also think--and I am only expressing a personal opinion here--that very probably the major difference is one of drafting and that with good will we can put this together.

I would like the Federal people to state their position on what they think they can go with and what they think they can't go with. Then if the agreement is that we are not likely to finish this today, I would suggest that the States get together with the people who aren't here--and hopefully they may be here tomorrow--and of those States who can be here, we will at least get your position, so that we will go into an executive session just between the States and the Federal people. A closed executive session tomorrow in Room--

MR. DICKSTEIN: Room 334.

MR. STEIN: Room 334. And the suggestion is, so you get this all cleared and to get as many people as we can, that we start the executive session at 10 o'clock tomorrow. At that time I think we will indicate that we will have a public announcement and come down here, say, perhaps at 2 o'clock. We can proceed with that.

But I think by raising the issues on these items and if more State representatives can get here or give their clearance by phone, we will be closer to taking a position tomorrow and getting done. That would be great.

I would very much urge, if at all possible, that you may want to consider having people like Thatcher and Reynolds, or whoever it is, at this executive drafting session, too, so that if there is any give we can all sign off on it and get this thing drafted up, if we possibly can.

With that I would like to call on Mr. O'Connell.

MR. O'CONNELL: The minor editorial changes in Roman numeral I and in the first sentence of Roman numeral II present no problems.

Roman numeral II(1), a suggestion was made to drop the introductory phrase, and there we would like to suggest an alternate introductory phrase which would read:

To minimize salinity increases in the river, a salinity control program generally as described in the Interior Department report be implemented.

As far as Roman numeral III or Roman numeral II(3) and Roman numeral III, the language suggested there presents certain difficulties for us which we think would warrant a meeting with the States in executive session, as the Chairman suggested, so that we might explain our relative positions to one another and perhaps find some possible areas of agreement. But as it stands, I think that that would probably be necessary to do that.

MR. STEIN: Unless the States want to indicate what their objections are to 3, both 3's, 3 under II and Roman numeral III, I think part of the operation was the question of what was achieved by making those changes.

MR. ROZICH: We felt that it was just clearer the way we had proposed the changes and come up with the same end in removing the four hundred.

MR. STEIN: I know what you are saying on that, Frank. Let me say this for the Federal position.

MR. ROZICH: All right.

MR. STEIN: I think that they think the drafting that was done has made some rather substantive changes. Now, if the objective of the States is just to make things clearer, I would suggest you look at this again and see if you can work with this as closely as you can to make it clearer, because the Federal judgment here when they looked at this was that this changed the sense of it, it wasn't just editorial or cleaning it up.

MR. ROZICH: Well, the other question we had was with regard to the construction starting date and completion date. I think all of us realize this is subject to congressional appropriation.

MR. STEIN: No. Now, I am not clear, and that is why I commend the use of footnotes aimed at this business of flexibility. I know we discussed this in the executive session last time. If we have adopted this approach that you have in (3), I think this is what came out. We adopted a project approach wherein you are going ahead with the project, and we are all going to presumably get behind certain projects and support them.

At least this was the theory, and this might be most expeditious. I think we were all in agreement with that, and this does it. Just like the story about everyone has a good idea for a Broadway show, but if you don't have the book and the music you can't get started.

Now, I just give you this. It would seem at least a recommendation. You have come out with something--they were talking about a date and when you are going to go. Now, if you have the notion, as Mr. Hume had, that this isn't an inflexible thing, obviously if you go ahead with the program you are going to make some, possibly, and not others, and you are going to adjust. But the question is, if you go to anyone that you are going to sell the project to, the first question he is going to ask is:

When do you want to do it? And

How much is it going to cost?

And if you don't come up with the dates, I think, again, these are the things that you may want to think out yourselves before we go. I am not arguing with these points.

MR. BALCOMB: Mr. Stein, may I say something?

MR. STEIN: Yes.

MR. BALCOMB: My name is Kenneth Balcomb. I speak for the Colorado River Water Conservation District. I am sitting back there in the back of the room, you understand, and, frankly, I don't know what you are talking about. If you are going to do something about the salinity of the Colorado River, if you are going to make some decision here, I think you ought to at least let people know what the hell you are talking about. I am serious.

MR. STEIN: By the way, I think you have a point about the difficulty--

MR. BALCOMB: I really don't know what you are arguing with your co-member about, you understand? That is what I am trying to say to you.

MR. STEIN: I understand it. Sir, I don't think I am arguing. I am trying to present two positions. I would hope that we would get this paper resolved and going. As a matter of fact, I don't think that I argued any position with Mr. Rozich.

MR. BALCOMB: Mr. Chairman, may I say this?

MR. STEIN: What?

MR. BALCOMB: You are discussing something with him about what you people are going to do. That is the thing I am talking about.

MR. STEIN: No, that is not so.

MR. BALCOMB: You are not discussing it with me, you are discussing it with him.

MR. STEIN: Perhaps I didn't explain this to you, sir. Maybe I should have done this, that is true.

What we are doing here--and there are many arguments against it, and I think you are proving the argument--what we are doing here is in effect, as I said before, is having an executive session with the audience sitting out there; make believe there is a wall. We asked for public participation. That part of the conference to this session has been terminated, but we let you come up.

Now, what these people have in executive session is a draft, and there are two language drafts on a particular paragraph. What I am trying to do is point out certain elements in these things which will enable the parties to get together and sign off on an agreed-upon draft so we can go home.

MR. BALCOMB: O. K.

MR. STEIN: All right?

MR. BALCOMB: My question, I think, really resolves itself around this. Do you think that seven of you can sit up here, or seven or eight of you sit up here, and resolve the salinity problem without talking to the people who are involved and contribute to that salinity?

MR. STEIN: Of course not.

MR. BALCOMB: I have had people tell me seriously, and I am from Glenwood Springs, you understand, that you people are attempting to dry up the Glenwood Springs Yampa pool. Well, I say, you know, this is a joke; this is a joke; you know, it really is a joke, because you can't do it. Factually you can't do it.

Now, what I am saying to you is that if you want really to know what people think about what you are doing, why don't you ask the people? You can't sit up here, you know, seven or eight or nine of you--and you are great people, don't misunderstand me. I am not criticizing you in that regard. You are trying to do the best job you can, but you can't do it this way. Why don't you go out and ask what the fellow who is sitting there on the piece of ground really thinks about this problem? Why don't you ask him one time and not be a totally, completely federally isolated person, a bureau, you know.

You have got great powers, don't misunderstand me. I am not criticizing your powers; I am not criticizing what you are trying to do. I am just suggesting to you, why don't you ask the fellow on the ground before you do something?

MR. STEIN: Well, I agree with you, and I hope that is--

MR. BALCOMB: Well, I have talked to your staff, you know, and I think you have got great staff people, but I am concerned about what you are doing; I really am concerned. You can't go down and tell my Grand Valley people, "You have got to curtail your diversion of water by 38,000 feet in order to solve a salinity problem," without telling them what they get out of it. This is what I am trying to tell you--that you have got to go back and talk to the people that are there on the ground. We can't sit here in Denver, we can't sit in Las Vegas, we can't sit in all these other places, you know, and be great big wheels.

MR. STEIN: I certainly agree with you, sir, and I--

MR. BALCOMB: We can't do that, you know, because when you--

MR. STEIN: I think your comments are well taken.

MR. BALCOMB: O. K.

MR. STEIN: Thank you very much.

MR. BALCOMB: Thank you.

(Off the record.)

MR. STEIN: Frank?

MR. ROZICH: Yes.

MR. STEIN: Do you want to go on with this?

MR. ROZICH: I think we can discuss it in the executive session.

MR. STEIN: Then we will meet in executive session at 10 o'clock in Room 334. Hopefully we will be able to make an announcement about 2 o'clock. And I suggest we all get the positions so we know where we stand.

With that we stand recessed until 10 o'clock tomorrow.

(RECESS)

The Conference reconvened at 10 o'clock on April 27, 1972, with the following parties present:

PRESIDING:

Murray Stein
Chief Enforcement Officer - Water
U. S. Environmental Protection Agency
Washington, D. C.

CONFEREES:

Irwin L. Dickstein
Director, Enforcement Division
Region VIII, U. S. EPA
Denver, Colorado

Norman B. Hume
Member, State Water Resources Control Board
Sacramento, California

Richard L. O'Connell
Director, Enforcement Division
Region IX, U. S. EPA
San Francisco, California

Frank Rozich
Director, Water Pollution Control Division
Colorado Department of Health
Denver, Colorado

Art E. Williamson
Director of Sanitary Engineering Services
Department of Health & Social Service
Cheyenne, Wyoming

S. E. Reynolds
New Mexico Interstate Stream Commission
Santa Fe, New Mexico

Carl Slingerland
Staff Engineer
New Mexico Interstate Stream Commission
Santa Fe, New Mexico

CONFEREES (continued):

C. C. Tabor
Chairman, Arizona Water Quality Control Council
Wellton, Arizona

Lynn M. Thatcher
Director, Bureau of Environmental Health
Division of Health
Salt Lake City, Utah

- - -

Conclusions and Recommendations

THURSDAY, APRIL 27, 1972

MR. STEIN: The Federal-State enforcement conference in the matter of pollution of the Colorado River has reached the following conclusions and recommendations. I am pleased to say that these conclusions and recommendations were reached unanimously by conferees representing 7 States and the Federal Government. They involve one of the largest river systems in the country and one of the most complicated problems we have —the control of salinity in the Colorado River. These conclusions and recommendations are as follows:

I. It is recommended that:

> A salinity policy be adopted for the Colorado River system that would have as its objective the maintenance of salinity concentrations at or below levels presently found in the lower main stem. In implementing the salinity policy objective for the Colorado River system, the salinity problem must be treated as a basinwide problem that needs to be solved to maintain Lower Basin water salinity at or below present levels while the Upper Basin continues to

develop its compact-apportioned waters.

II. The salinity control program as described by the Department of the Interior in their report entitled "Colorado River Water Quality Improvement Program," dated February 1972, offers the best prospect for implementing the salinity control objective adopted herein. Therefore, it is recommended that:

1) to minimize salinity increases in the river, a salinity control program, generally as described in the Interior Department report, be implemented on an accelerated basis;

2) the Bureau of Reclamation have the primary responsibility for investigation, planning and implementing the basin-wide salinity control program in the Colorado River system;

3) to accelerate the salinity control program, the Bureau of Reclamation assign a high priority to La Verkin Springs, Paradox

Valley, and Grand Valley water quality improvement projects with the objective of achieving stabilization of salinity levels on the Lower Colorado River at the earliest possible date. The contemplated impact would be to initiate immediate action so as to achieve, by 1977, the removal of 80,000 tons of salt per year from La Verkin Springs, 180,000 tons per year from Paradox Valley, and 140,000 tons per year from Grand Valley. This would provide a total reduction of 400,000 tons per year and would result in an estimated subsequent reduction of 33 mg/l at Imperial Dam.

4) the Office of Saline Water contribute to the program by assisting the Bureau of Reclamation as required to appraise the practicability of applying desalting techniques; and

5) the Environmental Protection Agency continue its support of the program by consulting with and advising the Bureau of

Reclamation and accelerating its ongoing data collection and research efforts.

III. To achieve the salinity policy described herein, the long range program of the Bureau of Reclamation shall be directed toward achieving reduction of salinity concentrations that would otherwise exist at Imperial Dam to the extent of at least 120 mg/l in 1980, 355 mg/l in 1990 and 405 mg/l in the year 2000.

The conferees agree that the Bureau of Reclamation's program as submitted in its report "Colorado River Water Quality Improvement Program," dated February 1972, should be considered as an open-ended and flexible program. If alternatives not yet identified prove to be more feasible, they should be included as part of the program, and if elements now included prove not to be feasible, they should be dropped. In addition, it should be recognized that there may be other programs which could reduce the river's salinity. Since present levels are greater than desirable, an effort should be made to develop additional programs that will obtain lower salinity levels.

The February 1972 report states that the Bureau of Reclamation Mathematical Simulation Model for the Colorado River system will be used to evaluate the Water Quality Improvement Program. This will be an important tool to evaluate the program's progress. The results of this evaluation along with the general program progress should be reported annually to the conferees and other interested State agencies.

This concludes the conclusions and recommendations of the conferees. I wonder if the conferees would feel they would want to add anything or modify anything at this time?

If not, I would like to--

MR. REYNOLDS: Mr. Chairman, I would like to make a point if I may.

New Mexico supports the conclusions and recommendations that you have read with the understanding that these conclusions and recommendations are in no way amendatory to or in substitution for the resolution adopted unanimously by the States at the February 15 session of the conference. I understand that these conclusions and recommendations are supplemental to that resolution. I think it is important for several reasons to point these out, not the least of which is the fact that the resolution that I mentioned contained the resolve of the States to very actively and aggressively support Federal financing for the program.

MR. STEIN: Thank you, Mr. Reynolds. That point is well made, and the conclusions and recommendations and that resolution I think are entirely compatible. The resolution, which is part of the record and will be made available to anyone who wishes it, as well as these conclusions and recommendations, was adopted unanimously by the States at the previous session of this conference. There were several portions of this resolution which, while appropriate for the States to comment, such as Federal financing, were not appropriate, because of the position under Federal law, for Federal people to endorse. Therefore, there was a reframing of these in the conclusions and recommendations we have here.

But both these documents set forth the

conclusions and the determinations of the State and Federal conferees and I think both of these will work completely together toward the same program.

Again I would like to thank all the States very much for their efforts here, because I do think with this unanimous agreement we have achieved the first step in what promises to be one of the major breakthroughs in achieving high quality water in the United States, and that is the control and reduction of the salinity in the Colorado River system. This is a very difficult and vexing problem, often not associated with discrete point sources such as industries and municipalities which cause degradation of water quality in other river systems, and it is only with the full cooperation of Federal and State agencies and groups and governments that we can hope to achieve the result. I think with the good will shown here by all the States concerned that we have made the first step up on the problem and that this has been a very, very successful conference. I will be happy to take these recommendations and conclusions back to Washington.

Before we throw this open for questions from the press, are there any other comments you have?

MR. HUME: Mr. Chairman.

MR. STEIN: Yes.

MR. HUME: California is especially pleased at the very fine recommendations and report contained in the February 1972 Bureau of Reclamation report which formed the basis of much of the deliberations in connection with the formation of this resolution which we have before us.

I think that one of the things of great import with respect to this are the last two paragraphs which you read, which says, in essence, that we are not bound by either the technology or the mentality now brought to bear upon this problem, but we are looking to the future also to bring up considerations which might prove even more fruitful than the items which we have deliberated upon at length in this document, and we are very pleased that we could be forward-looking about a program of such tremendous consequence to a great portion of the United States.

MR. STEIN: Thank you.

Are there any other comments?

MR. REYNOLDS: If I may, Mr. Chairman, perhaps two points.

Mr. Chairman, as you know, Mr. John Wright of the New Mexico Environmental Improvement Agency served for several years as New Mexico's representative on this conference. Mr. Wright and I mutually proposed to the New Mexico Water Quality Control Commission that the New Mexico State Engineer be named to serve as New Mexico's conferee on the conference and that John Wright serve as his adviser, and the Water Quality Control Commission did approve that proposal.

One further point, Mr. Chairman. On behalf of the State of New Mexico I want to express great appreciation of the attitude of cooperation exhibited by the Environmental Protection Agency of the United States in this very difficult problem, and I want to say that I share your enthusiasm for this approach to the solution of the Colorado River salinity problem.

MR. STEIN: Before we close, I really extend a special thanks to the Bureau of Reclamation. While we know that the Department of Agriculture has been working with us, I think it should be recognized that the basic blueprint for the action program we have agreed on today has been developed by the Bureau of Reclamation under its statutory authority and the major responsibility for carrying this out will be with the Bureau of Reclamation. I know for a while I was in the Department of the Interior as our agency was passing through, I always loved working with the Department of the Interior people there, and I really am looking forward to working with you again on this project.

Are there any other comments?

If not, with that we will conclude the conference. But the conferees will remain here for any questions that may be asked and you can ask the questions to whomever you choose.

With that, the conference is concluded and thank you very much.

(Whereupon the conference adjourned.)

- - -

☆ U. S. GOVERNMENT PRINTING OFFICE : 1972 722-874/463